Some Reminiscences of Niagara

By P. M. Lincoln, President 1914–15

Although almost microscopic as compared with modern electric generators, the 5,000-hp generators installed at Niagara Falls in 1895 had a capacity of about 4 times that of the largest generator previously built. Some of the early operating experiences at Niagara are related here by a past-president of the Institute who was the first operating superintendent and who was in charge of the construction and operation of the original Buffalo-Niagara 11,000-volt 3-phase transmission line.

ELECTRICAL equipment of the Niagara Falls Power Company, which began operation in 1895, was unique in many particulars. First, it was unique in size. The electric generators installed at Niagara Falls in 1895 were of approximately 4 times the capacity of the largest previous electric generators that had ever been built. They were rated and were capable of carrying 5,000 hp. This rating is, of course, almost microscopic when compared with some of our present-day generators; but nearly 40 years have passed since the starting of the Niagara plant. I think I am correct in stating that the Niagara generators represent the largest *single step forward* that has ever been taken in generator design. It speaks well for the ability of their designer, Mr. B. G. Lamme, to note that these generators are still in operating condition and even now are used occasionally to carry a part of the Niagara Falls Power Company's load. That they have been taken out of regular service is not due to any deficiencies of the generators.

One of the farseeing innovations that Lamme introduced into Niagara generators was the use of mica as the insulation on the armature conductors. This choice of mica was fortunate. Tests made many years later showed temperature rises in the armature conductors that were totally unsuspected during the operation in the earlier years. These later tests showed temperatures of the order of 200 deg C under the heaviest loading conditions. The fact that Mr. Lamme's mica insulation stood up for many years under any such temperatures is not only a tribute to his genius in selecting mica as the insulation, but also is a commentary on the temperature measuring methods of that early day.

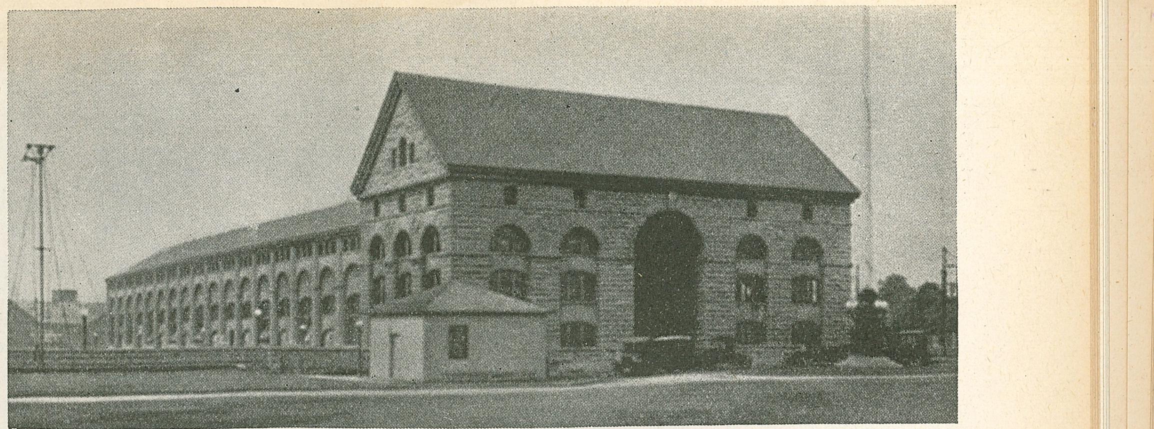
Another unique feature of the first Niagara plant was the design of the exciting system. While we can justly say that remarkable foresight and genius marked the design and construction of the first Niagara generators, the total absence of these qualities marked the design of the exciting system. It seems incredible, but it must be recorded, that the only exciters provided for this first Niagara plant consisted of rotary converters, which were to be run from the main bus bars. Fortunately, there was available in a neighboring building a direct-current steam-driven machine which had been used in connection with the construction of the wheel pit and water tunnels; this machine was used to excite the main generator for the purpose of starting the rotary converters that in turn were to be used for exciters. In case of an accident that would shut down the entire plant, we were helpless, of course, without this steam driven machine to enable us to start up again. For the first 2 or 3 years of operation it was therefore necessary to keep this steam driven machine either running or ready to run at a moment's notice, to guard against a total shutdown of the main plant.

A more unsuitable design for an exciter system could not be imagined. At the end of the first 2 or 3 years' operation, water wheel driven exciters were installed; and not until then were we free from the necessity of keeping this steam driven unit constantly ready for instant service. It is a commentary on the state of the art at the time that such an oversight could have occurred in the design of the exciter system.

Still another unique feature of the Niagara plant was the frequency adopted—25 cycles. The circumstances that led to the adoption of this frequency are set forth by Mr. Edward D. Adams in his "History of the Niagara Falls Power Company" (v. II, p. 236–8). As Mr. Adams points out, 25 cycles was a compromise. It is worthy of note, however, that 25 cycles became a standard frequency and was subsequently used to a considerable extent, particularly in the United States.

Niagara was unique in that it was primarily intended for *power* rather than *light* as were most of the preceding electric installations. It was one of the earliest and by far the largest electric power installation of the time. It was unique further in that the methods used for the generation and distribution of power were new and untried—at least on the scale attempted at Niagara—namely, *alternating current, polyphase*. Practically all the users of Niagara service were *power* users. The first user was what was then called the Pittsburgh Reduction Company, now the Aluminum Company of America. That plant started on August 26, 1895; it soon was followed by the Carborundum Company and soon after that by the Union Carbide Company. Other loads followed rapidly. The plant was successful from the beginning. There were troubles, of course, but none insurmountable.

Exterior of Niagara Falls power house No. 1



Early users of Niagara power were local, located not over a mile from the power house. With the success of the local use of power, there naturally came consideration of its transmission to neighboring cities, particularly Buffalo. There was naturally quite some misgiving as to our ability to give satisfactory service in Buffalo, but this step was undertaken the year following the starting of the Niagara plant, that is, during the autumn of 1896. Many new problems arose in connection with the transmission of Niagara power to Buffalo. I think I can do no better than to quote from a report that I prepared some 15 years ago for incorporation in Mr. Adams' history of Niagara Falls.

[EDITOR'S NOTE: The remainder of this article is republished from "Niagara Power, History of The Niagara Falls Power Company, 1886–1918," by Edward Dean Adams, v. II, p. 276–86. These 2 volumes were published privately in 1927 by the Niagara Falls Power Company, Niagara Falls, N. Y., on the fiftieth anniversary of its foundation.]

REPORT OF OPERATING SUPERINTENDENT

The supervision of the details of material and erection of the transmission line was the responsibility of the company's resident electrical engineer and operating superintendent, Paul M. Lincoln, who describes his work in this connection by the following statement made in 1920:

The first Niagara-Buffalo transmission line on the American side of the Niagara River went into service during the fall of 1896. As the operating superintendent for The Niagara Falls Power Company, it became my duty to supervise the operations of this transmission line from the time it went into service in 1896 until I severed my connection with The Niagara Falls Power Company in May 1902.

The status of electrical transmission as of that date has been set forth in the preceding chapters. Suffice it to say that at that date the use of alternating currents for lighting was only 10 years old and its use for power purposes was almost unknown. The few previous attempts to use alternating currents for power purposes were exceedingly crude and were on a much smaller scale than that proposed for the Niagara-Buffalo transmission.

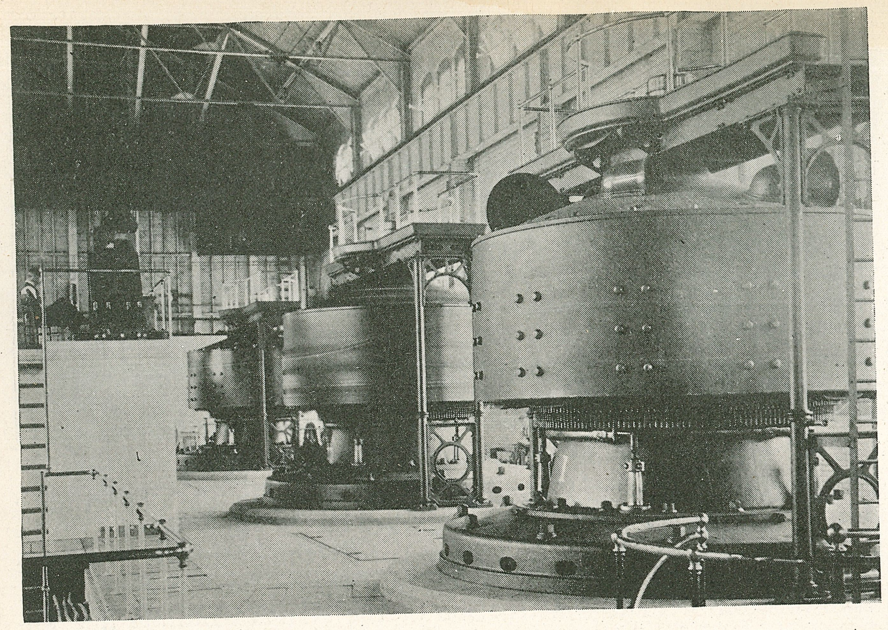
In the construction of the Niagara-Buffalo transmission line, such precedents as then existed were followed. These precedents in turn had followed the practice of telegraph construction—the only precedent there was to follow in that day.

The following statement is based on my personal recollections of 6 years' direct contact with this transmission, and is reinforced by the opportunity which has been afforded me of perusing the correspondence that passed at the time when the purchase of equipment for this transmission was contemplated.

The construction of the Niagara-Buffalo line followed the recognized practice of the period for telegraph lines—the only precedent there was to follow at that time. The poles, cross arms, pins, and insulators were of course heavier than those used in telegraph practice, also all poles on curves were either braced or guyed. At corners, double poles were used, but in other than these details construction was very similar to that used in the telegraph practice of the day.

The photographs reproduced herewith show but a single line on the poles; this is because these particular photographs were taken before the second line was erected. To meet the problem of continuity of service it was essential to have more than one transmission line available for use at all times. Two such lines were installed at the beginning, either one of which would easily carry all the power taken by Buffalo during the first few months or year. It was always the policy of The Niagara Falls Power Company to have a sufficient number of lines in service so that at any time one line could be shut down for inspection or repair and the remaining lines could easily carry all the power required.

The Niagara-Buffalo line was a relatively short one, only about 22 miles from the step-up station in Niagara to the step-down substation in Buffalo. Today this would hardly be called a transmission, but rather an enlargement of the distribution area. Also, the voltage used was not high—11,000 volts—3-phase—a voltage that today would be viewed as a distribution voltage. Other plants, even at that time, were transmitting power at higher voltage than that. However, in some aspects the Niagara-Buffalo transmission was unique and of historical importance. In the amount of power transmitted and in the importance of the service rendered by the transmitted power, the Niagara-Buffalo transmission transcended anything that had been attempted previously. The first load in Buffalo to be operated by this transmitted power was the street railways of Buffalo. Any failure of transmitted power was, therefore, heralded immediately throughout the entire community. Other loads were soon added which were almost as important. The first requisite for trans-



Original 5,000-hp 2-phase Niagara generators

Although the a-c system had been pronounced impossible for Niagara, these Westinghouse generators, built in 1894–95 and several times as large as previous a-c machines, are still operating. The external revolving field design prevailed for the first 10, then the internal revolving field was used.

mitted power was therefore *continuity*. It soon developed that the success or failure of Niagara power in Buffalo depended on keeping the supply *continuously* available in Buffalo. Then, therefore, began the long battle for *continuity of service*, a battle that has been waged not only on the Niagara-Buffalo line but on every other transmission line that has gone into service since then.

In 1896, transmission line equipment was not what it is today. Lightning arresters were totally inadequate; the oil switch was not yet known; the insulator was woefully defective and such a thing as reversed power protection was not even dreamed of. The experiences of the Niagara-Buffalo transmission were to have a material effect on the evolution of transmission technique.

Lightning

Lightning was one of the first as well as one of the most formidable enemies that the Niagara-Buffalo transmission had to fight. There never has been a complete answer to the lightning problem, but at that period there was hardly even a beginning to the later progress. The bettering of line insulation and construction has been one of the chief factors that has reduced interruptions from lightning. Nothing has been developed that has eliminated *all* interruptions from lightning and in my opinion there will be no such development. A direct stroke of lightning is almost sure to cause an interruption of service on the line affected; if, beyond this, equipment attached to the transmission line is not destroyed, the operators may consider themselves fortunate. Direct strokes, however, are not common and it is a lucky thing for the transmission of electric power that this is the case. But there are severe strains imposed on the insulation of transmission lines and the equipment connected thereto whenever lightning occurs anywhere in the neighborhood of a transmission line. The severity of these strains depends on the severity of the lightning discharge as well as its proximity. Against these indirect effects it is possible to secure some degree of protection. In 1896 the amount of protection that could be secured was an unknown quantity.

Alexander J. Wurts of the Westinghouse company had been doing valuable work on the problem of lightning protection. (See paper by Mr. Wurts, A.I.E.E. Trans., March 1892 and May 1894.) He had developed a so-called "nonarcing" lightning arrester, a series of cylinders made up of metal that would permit the lightning discharges to pass, but presumably would prevent the generator current from following. These arresters were tried out on the Niagara-Buffalo transmission line with considerable hope that they would perform as expected. However, it was soon found that the low frequency in use on the Niagara system coupled with the large amount of power in the installation back of the line, caused almost a complete failure of the so-called "nonarcing" properties of these arresters. An arrester which would operate with perfect success on a system of a few hundred kilowatts failed utterly to quench the arc when the Niagara generators were back of that arc. This was one of the points where the size of the Niagara system introduced a new problem. It was found that in order to make these arresters suppress the arc successfully it was necessary to introduce a resistance into the discharge circuit to limit the amount of current that could flow. This in turn limited the effectiveness of the arresters.

Both the Westinghouse and the General Electric companies worked ardently on this lightning arrester problem but neither was able to produce a complete solution. In fact it has always been a serious question in my mind if the lightning arrester on the Niagara-Buffalo line accomplished anything at all toward continuity of service. There may have been some occasions when the arresters took care of lightning surges that might have caused damage and interruption of service without them; also there were other occasions when the failure of the arresters to quench the generator current caused service interruptions that would have been avoided if there had been no arresters. The use of lightning arresters on transmission lines is still a mooted question. In general it has been found that the higher the voltage of transmission, the less necessary lightning protection becomes. With the very high voltage used in some of our latter-day transmissions, the voltage strains caused by lightning are but little if any higher than the normal voltage strains. The higher

the voltage used for transmission, the less necessary becomes lightning protection, due to the fact that the operating voltage requires so high an insulation. All this, however, was not known in 1896, and we at Niagara had to pass through the labor pains of the birth of this knowledge.

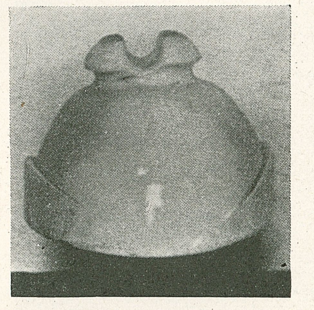
The design and construction of the first Niagara-Buffalo line incorporated one method of protection against lightning that proved disastrous. Theoretical considerations indicated that grounded guard wires over the transmission lines would be effective, at least to some degree, in shielding the transmitting conductors from lightning. Three such guard wires were installed on the original line. Unfortunately, however, the material selected for these guard wires was standard barbed fence wire. So long as the guard wires remained intact they were undoubtedly effective to a considerable degree in protecting the line. But the material of these guard wires was not equal to the strains put on them in this service and occasionally they would break and fall across the transmitting conductors below. This would cause a short circuit and usually a complete interruption of service. The worst of it was that often service could not be restored until the broken guard wires had been found and removed. Guard wires, therefore, were not found to be conducive to continuity of service in this case. After the experience of a few of these guard wires being broken, the guard wires were removed.

In passing, I might remark that this experience has not shaken my faith in the efficacy of guard wires as protection against lightning. It is still my opinion that guard wires properly installed constitute the best protection available against lightning; however, the "properly installed" should be emphasized.

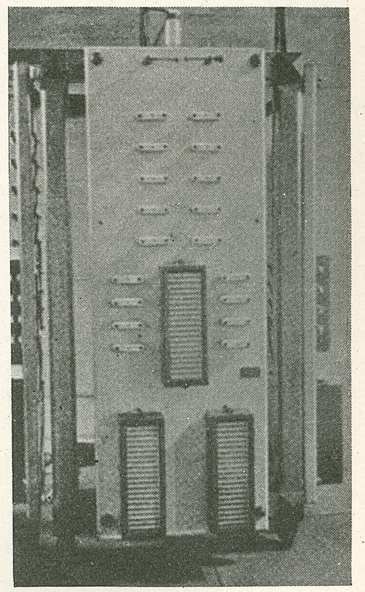
To recapitulate, lightning was probably the greatest single cause of service interruption on the Niagara-Buffalo transmission, partly because of the severity of lightning storms on the Niagara frontier and partly because of the insufficiency of knowledge in methods of combating the difficulty. Not a small part of this knowledge resulted from our experience on this particular transmission line. While we were not able to obtain perfect protection from lightning, the interruptions we were getting at the end of my 6 years' connection with the Niagara-Buffalo transmission were not so serious as at the beginning. We were continually getting the better of the problem of interruption by lightning. This is evidenced by a record of more than a year's operation without a single interruption of service from lightning or any other cause—a record that has been made by this Niagara-Buffalo transmission.

Line Insulators

The line insulator constituted another problem that we on the Niagara-Buffalo transmission had to meet and meet with but little previous experience to guide us. The early transmission lines followed the practice already set by the telegraph. The only previous departure from this practice had been the Frankfort-Lauffen transmission in Germany during 1891. In that installation, power had been transmitted from a water-power [station] at Lauffen to the city of Frankfort—a distance of about 100 miles. 30,000 volts was used in this installation—a voltage far above anything that had been used previously. The installation was not intended to be a permanent one. One of its main purposes was to advertise an exposition then going on in the city of Frankfort, and it was more or less of an experiment. The insulators used on this transmission were provided with an oil cup so designed that an oil covered surface was interposed into the path of any leakage current over the surface of the insulator. At that time, it was not considered practicable to use any other type of insulator on so high a voltage. It is also noteworthy to observe that in its earlier proposals for the insulators on the Niagara-Buffalo line (made either late in 1893 or early in 1894) the Westinghouse company proposed to use similar oil filled insulators. Apparently the oil filled insulator idea was later abandoned and both the Westinghouse and the General Electric companies proposed insulators of the general type later adopted. This is of interest as indicating the unsettled state of the transmission art at this early day. The drift of actual practice has been entirely away from the oil filled insulator. So far as I know, the Frankfort-Lauffen transmission was the only case in which oil filled insulators were ever actually used in power transmission, but they



Helmet type insulator used on original Niagara Falls-Buffalo transmission line

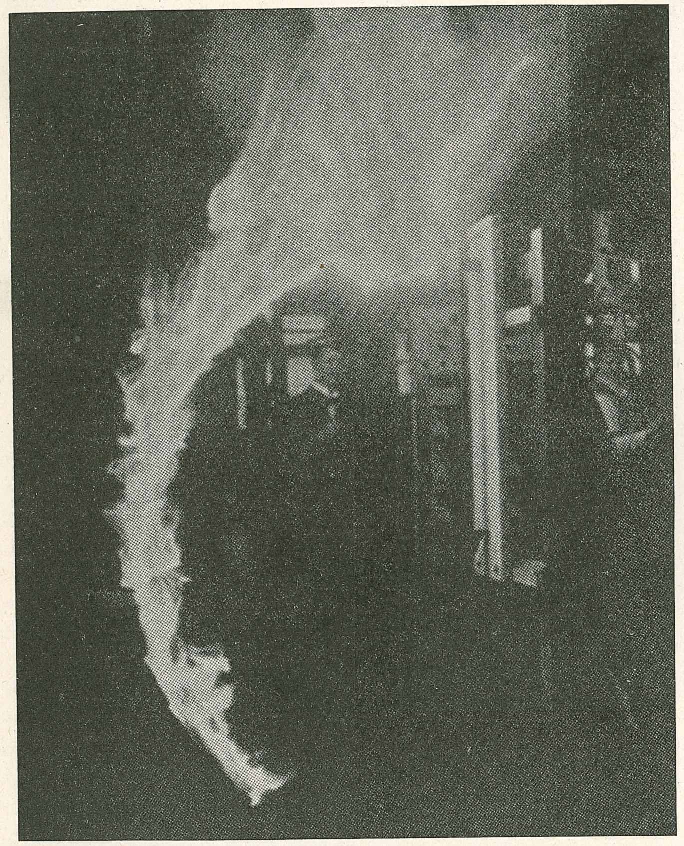


(Right) Wurt's lightning arresters at Niagara end of Buffalo transmission circuit, 1913

were seriously considered in 1893 or 1894 for use on the Niagara-Buffalo line.

There were a number of designs of insulators tried out on the Niagara-Buffalo line. In every case the material was porcelain, but the shape, size, and method of manufacturing differed. Among other types a large number of porcelain insulators made by the dry process were installed. These insulators were more or less porous and after some months of operation would absorb enough moisture to become slightly conducting. This in turn would lead to the burning of pins, cross arms, and pole tops. Many difficulties of this nature were encountered and

eventually all insulators of this type were taken down and rejected. To eliminate insulators of this character we developed the method of soaking them in salt water, using a salt water bath in which the insulators were partially immersed upside down and then filling the pin hole with salt water and applying the test voltage between the water in the pin hole and that of the bath. After this method of test had been adopted the defective porous insulators were quickly detected and rejected. In all about 40,000 of these dry process insulators were rejected in connection with this transmission. In many cases, however, the rejection did not take place until after the insulator had been in service for some time and



Fuse-release 10-kv Niagara circuit breaker

Melting of a fuse released a hinged arm 4 ft long which fell, drawing a momentary long arc. This type was used on the early Niagara Falls-Buffalo circuit

had had the opportunity to contribute its quota against us in our battle for continuity of service.

Except for our disastrous experience with these dry process insulators, the porcelain insulators we used at Niagara were fairly satisfactory. We knew more about the insulator problem after our 6 years' experience than we did before, of course, and the design and construction of porcelain insulators received a decided impetus from this experience. It is worthy of note, too, that one of the modern underlying types of insulators—the Hewlett-Buck insulator (suspension type now almost universally used on high voltage lines)—had its origin in connection with the Niagara-Buffalo transmission line. This particular type of insulator was not used, to be sure, on this first line but the problems of this line induced its conception.

Switches and Protective Devices

In 1896, protecting devices for transmission lines were conspicuous by their complete absence. The oil switch had not yet been conceived and there was no method known by which a short circuit on an operating transmission line of the capacity we had at Niagara could be opened without shutting down the entire system. The only overload protection we had at the beginning of operations was fuses. It soon developed that the fuse under these conditions was a menace and not a protection. The amount of power to interrupt was so large that the fuses of that day could not begin to interrupt a short circuit successfully. After this fact had been demonstrated by several sad experiences, all fuses were removed. The only alternative was so to arrange that the entire plant would be shut down in case of a short circuit. This was accomplished by causing the field circuit breakers on the generators to trip in case a short circuit came on and persisted. Since most of the short circuits occurred on the Niagara-Buffalo line, it soon became necessary to separate the transmitted load from the local load so that an interruption on one need not involve the other. There were a great many more short circuits on the transmission line than there were on the locally supplied load and the local load users objected strenuously to being shut down every time a short circuit occurred on the transmission lines. Hence the separation of the 2 loads.

The necessity of shutting down the entire system whenever a short circuit occurred pointed strongly to the necessity of securing a switch that was capable of interrupting a short circuit. No such switch existed at that time and the problem was put up to the manufacturing companies for solution. The General Electric Company started the development of the oil circuit breaker while the Westinghouse company preferred a design that used long air breaks. As development proceeded and experience was accumulated it was apparent the General Electric Company had chosen the right path in this case. While air break switches might be satisfactory on the 11,000 volts that the Niagara-Buffalo line started with in 1896, it became evident as experience accumulated that with higher transmission voltages which was expected to be adopted within a few years, the air break switch would not be satisfactory. Even with the 11,000-volt transmission, their operation was far from satisfactory. I personally saw its operation on one occasion when a heavy short circuit caused the opening of one of these air circuit breakers. The arcs drawn were at least 6 feet long and maintained for nearly 15 seconds. The results obtained were so unsatisfactory that we went back to the method of interrupting the entire load in case of trouble.

One of the earliest models of the oil switch was brought to Niagara Falls by the General Electric Company for trial. The early trials indicated that

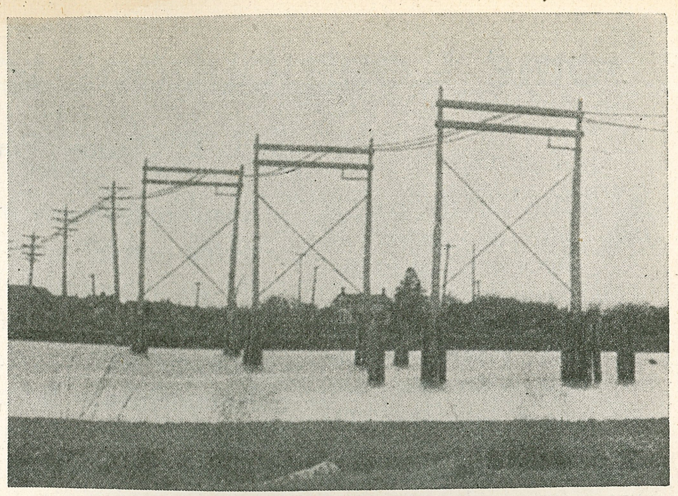
this method of attack would be successful—and experience later proved this to be the case. Today, no one would think of using anything but an oil switch with voltages and amounts of power such as we were dealing with at Niagara. The General Electric Company was the first to make a move toward using oil to quench the arc in switching, but soon after it had proved successful the Westinghouse company followed and today not only these 2 companies make this type of equipment, but many smaller companies also. The significant thing which I wish to emphasize here is that when the Niagara-Buffalo line began operations, there was no known method of successfully interrupting a short circuit. Our only method of procedure was to shut off the entire power supply under that condition. It was one of the handicaps of being a pioneer in the transmission game. This particular handicap was a very serious one since our battle at Niagara was to secure *continuity of service*. By the method of operation we were obliged to adopt, every short circuit on the transmission system meant a total interruption of power. It was, therefore, our endeavor to reduce the short circuits on the transmission line to a minimum.

Before leaving the subject of switching, perhaps a word concerning the first switchboard installed with the original generators might be in order. One of the items of this board was a series of air operated switches. When these switches were designed and built in 1894–1895 they were the best that the art afforded. It was confidently expected that they would be able to interrupt any load that might be thrown upon them. However, it required but a very brief experience after the first generators had been put into operation to realize that these switches would be totally useless to interrupt short circuits. They were used as synchronizing and disconnecting switches but beyond that they were useless.

In passing it might be observed that this problem of interrupting short circuits on the very large capacity high voltage modern transmission lines has proved to be one of the most difficult that the transmission engineer has met. The oil switch has proved the best means of meeting this problem that has been found, but even the largest and most powerful oil switch made is taxed to its utmost with some of our larger power systems behind it. Continuity of power supply requires that some means be used to disconnect defective portions of a transmission system and allow the remainder of the system to go on supplying service to the unaffected portions of the system. The need of such a switch was recognized in the early days of the Niagara-Buffalo transmission but we had to struggle along without it.

Interruptions From Miscellaneous Causes

Two other causes of service interruption were met on this Niagara-Buffalo line, *viz.*, accident and malicious mischief. While accidents were not common, they did occur occasionally. For instance, on one occasion a dredge operating in the canal, along which ran the transmission line, raised its dipper into the line, thereby short-circuiting the line and temporarily shutting off Buffalo's power. On another



Original Niagara Falls-Buffalo 3-phase 11-kv line

occasion, a cat crawled in behind the lightning arresters in the step-up transformer station and caused a complete short circuit and shutdown. Another very peculiar case occurred when a gang of men were cleaning the right-of-way from trees. A tree being felled, struck the end of a crooked limb lying on the ground and caused it to ricochet into the air; by an unlucky chance it fell across the transmission line and lodged there. The limb was green and just conducting enough to carry some current from conductor to conductor. The limb on the conductors confined this current to the point of contact and the burning continued until the transmission conductor itself was entirely burned apart and fell to the ground. This accident not only interrupted power supply to Buffalo, but it completely disabled that line until repairs could be effected. On still another occasion lightning caused an arc to form between the transmission conductor where it emerged from the step-up substation at Niagara and the edge of a metal canopy that had been erected to protect the conductors at their point of entry. This arc continued until the conductor was burned in two.

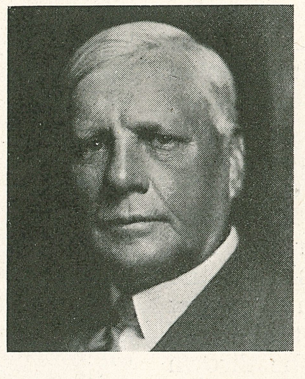
Some little trouble was caused by malicious mischief makers. The ubiquitous small boy found that he could cause a very spectacular display of fireworks by throwing a piece of wire over the transmission line. He little realized that he thus deprived momentarily a whole city of its power supply. Proper coöperation with the local police authorities along the line reduced this mischief to a minimum.

I might go on indefinitely giving instances of the difficulties that we encountered on this early power transmission. They all lead to one conclusion; we were pioneers and we suffered the fate of all pioneers. The road we were traveling was not yet illuminated by the light of experience. We had to grope our way. We were not wholly unsuccessful in lighting the way for others to follow. The Niagara-Buffalo transmission was a success both from a financial and from an engineering standpoint. The battle for continuity of service was waged and won. It has always been a matter of no little self-satisfaction that we at Niagara have helped to blaze the trail that since then has become a much traveled highway.

Some Contributions to the Electrical Industry

By C. C. Chesney, President A.I.E.E. 1926–27

Some outstanding individual contributions of the past 50 years to the electrical industry are reviewed here by a past-president who himself has made no small contribution; he says: . . . "as we of the electrical fraternity hope for continued progress, we must remember that our hopes can be fully realized only by remaining true to the greatest of our traditions, 'to produce and to serve.'"



AS WE LOOK BACK into the history of the electrical industry and visualize the past 50 years, we can hope, yea, expect that future accomplishments in the electrical world will be fully as eventful as the unmatched events of the past. Promises that come from home and abroad are filled with predictions of continuous progress.

This optimistic sentiment, emanating not from one but from all of the many responsible sources throughout the world, applies not only to the business side, but also to the scientific side of the industry—to the central station business for furnishing light and power, the core of the industry with its investment values already reaching the \$10,000,000,000 mark, a value greater than the combined value of the industries of England of the Gladstone period when Michael Faraday made his fundamental discovery of magnetic induction in 1832. It applies also to the possible future accomplishments of the research laboratories, forecasts of which are to be found in the accomplishments already given to the world by these institutions.

These forecasts are full of hope, so far as it is given to fallible man to read the future, and they may well bring pride to the heart of the electrical engineering fraternity as well as to the whole world. Coupled with that pride is a spirit of gratitude on the part of the present generation of engineers toward those who have given their lives and their leisure in establishing the fundamentals on which electrical science and industry are built.

In that spirit I am prompted at the outset to dwell upon the versatile achievements of Thomas A. Edison. However, as my association has been entirely with that part of the art which had to do with the manufacture of generating machinery for the transmission of power by the use of alternating currents, I propose to review the early history of the electrical profession for outstanding individual contributions peculiar to the development of the science and art of transmitting power by the use of alternating currents.

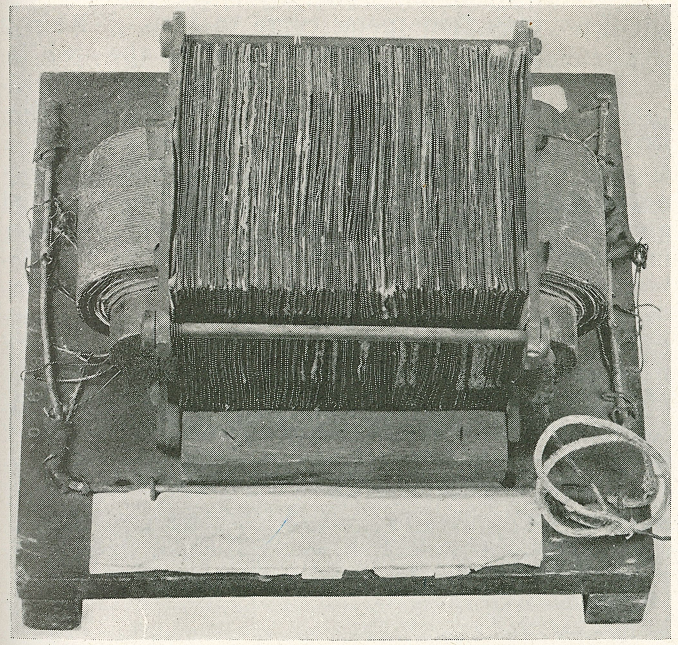
The salient feature of the art of generating and distributing power at the present time is the superpower system, that is, an interconnection of existing and prospective generating and distributing systems. The broad idea of the superpower system must continue to grow more and more, because it is economically sound. It brings about an improvement in the load factor of the generating system; it allows the metropolitan markets for power to be connected in a continuous system with remote power reserves, and makes the exchange of energy from one part of such a system to another a practical, reliable, and everyday occurrence. Many are the engineering problems involved in the safe operation and satisfactory service of an interconnected system. However, electrical engineers already have solved these problems or are well advanced in their solution. For instance, the spreading of the troubles of one system to the next (bugbear of the past) is prevented by proper relaying and sectionalizing.

The holding of the proper voltage at different points, and the prevention of the flow of wattless current, are accomplished by adjusting automatically, if necessary, the ratio of the transformers so that the voltages at the point of connection may be of the same value and have the same phase relations. The interconnection of electric systems constitutes also an important progress in civilization, because it aims to allow electric energy, like sunlight, to become available everywhere.

It is well known that a discovery in the sciences is not an isolated event. The laws of nature have ordained that progress or change is never by leaps or revolutions. This is true, of course, of electrical engineering and the branch of it that deals with long distance transmission of power by means of alternating current. It has grown as does a snowball, by the process of almost infinitesimal additions. Practically every experiment or new development in the generation, transmission, and conversion of electric power is a modification of an experiment that has gone before. Almost every new theory is built through the contributions of many workers, of many different elements, one adding a little here and another a little there; thus to the observer in retrospect, progress seems to be continuous and uniform.

I wish, however, to emphasize the fact that the changes introduced into the art during the early '90's of the last century by the engineers of that period have placed the whole structure of electrical art of today as applied to light and power, firmly on the use of alternating currents. These changes have made economically possible the generation of large amounts of power in suitably located central stations, and its conversion and transmission to those points where it can be used most advantageously by industry to operate and to increase the capacity and the economy of our mills and factories; to provide electrical transmission to the small town and country; to extend and improve the processes of metallurgy; and now to place in the homes of the great agricultural classes, through the use of electric power, the comforts and conveniences of the city, and to place in the hands of the farmer the opportunity to extend the economy of the farm to a point where it may compare favorably in efficiency and effectiveness with the factory and the workshop. Thus will the nation be prepared, through the aid of the superpower systems, for a complete decentralization of industry, which is needed ultimately to relieve the economic stress of both farm and city.

Nevertheless, to me the outstanding accomplishments of this period which made for the greatest progress were: the broad generalization of electrical phenomena, and the mathematical formula for the design of alternating current machinery by Charles P. Steinmetz; the invention and development of the modern transformer by William Stanley; the invention of the induction motor by Nikola Tesla;



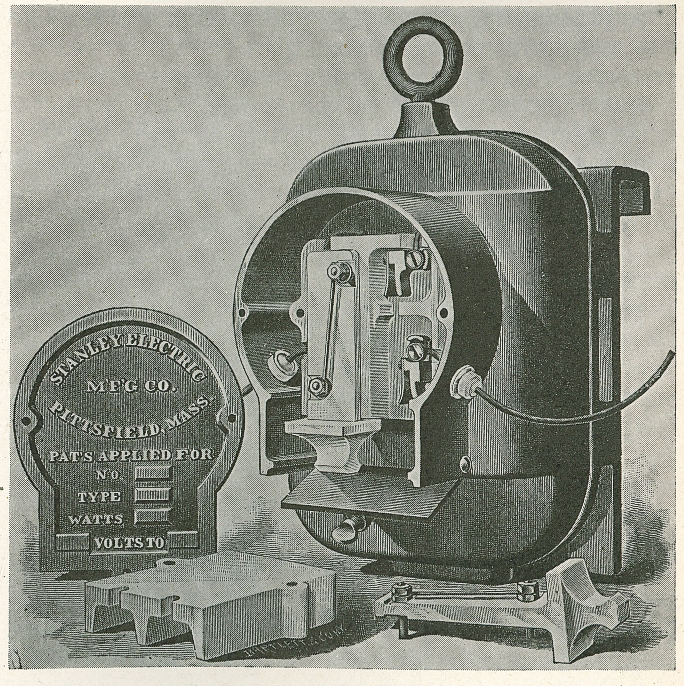
The original transformer built by William Stanley in 1885

the induction meter by Oliver Shallenberger; the dynamo-electric machine by Benjamin G. Lamme; and the numerous contributions to all branches of electrical machinery by Elihu Thomson.

In 1886, William Stanley, in the first alternating current plant in America, which was engineered and built by him at Great Barrington, Mass., demonstrated how electric power could be generated at a low voltage, transformed into a higher voltage, transmitted at the higher voltage, retransformed to a lower voltage, and used at this voltage as might be required. This feature of adapting the voltage to varying requirements, and of maintaining it substantially constant, irrespective of the load, rendered possible the enormous development and progress in the distribution and transmission of electric energy that have taken place since.

This capability of voltage transformation lies in the transformer itself, insignificant though it may appear. Stanley always spoke of the transformer as the "heart of the alternating current system." Naturally the great development of the art has been accompanied by a similar development of the transformer. Very early Stanley had properly visualized the fundamentals of transformer design, and correctly solved many of its problems in the Great Barrington installation. This revealed a thorough understanding on his part of electromagnetic induction, rather surprising for 50 years ago. The same ability in handling these laws as applied to transformers was shown by Stanley in the construction of the inductor alternator, which had no windings on the rotor, a feature considered of much value at the time. The inductor alternator, as well as the Stanley induction motor and the Stanley induction meter, did not survive; but the transformer did, and is substantially the same as the one originally built by Stanley.

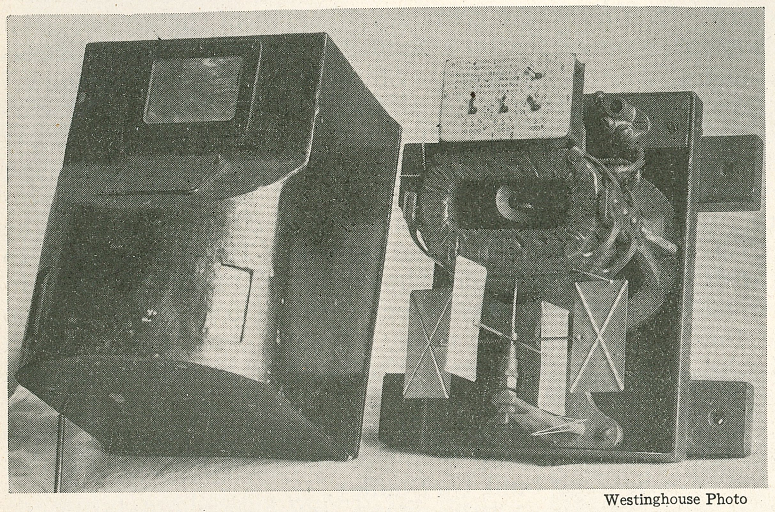
The possibilities of the alternating current system early appealed strongly to the imagination of electrical engineers, both at home and abroad, but they appealed to none more strongly than to William Stanley. At 30 years of age he had a full conception of the alternating current station idea of manufacturing power, that is, the manufacture of power in



An early Stanley commercial transformer with front plate removed showing arrangement of fuses

large volume in some suitable location, transmitting and distributing it to points of consumption by the use of alternating current. With this idea firmly fixed in his mind, and fully determined to find out at

Pittsfield, Mass., whether there were any limits in sight barring the use of line potentials higher than the 2,000 volts then generally employed, he instructed me to design and build, in 1892, transformers and a line for 15,000-volt operation. To this end



Westinghouse Photo

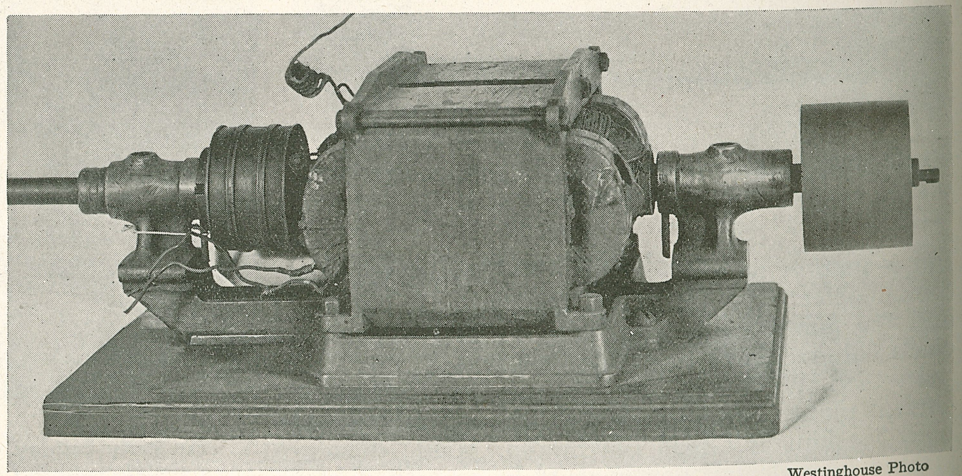
Induction type ampere-hour meter invented by Shallenberger in 1888. This was the first a-c integrating meter, and it is the parent of all a-c watthour meters now in use

we erected a pole line, built a transformer house, and set up the transformers. These increased the potential of the town circuit from 1,000 volts to 15,000 volts. We connected the line to this high potential supply, sent the current around a farm and back to the same transformer house, then retransformed the line potential to 1,000 volts, and operated the distribution transformers of the local company. This little plant was operated during a New England winter with entire success, and the engineering data obtained were the reason for subsequent recommendations by the Stanley Electric Company for the use of potentials much higher than 15,000 volts. I recall these facts only to emphasize the undeveloped state of the art of that early period of which I speak, and how limited and provincial was its outlook compared with our present-day accomplishments.

Nikola Tesla invented the induction motor in 1888. This invention was a great step forward, and it has been stated frequently that the invention of this motor was one of the greatest advances made in the industrial application of electricity. This statement without doubt is true, but the development of the motor was long and costly, and as late as 1895 it was still in the experimental stage. Vital reasons for its slow progress, development, and application were: First, it was primarily a polyphase motor, and the alternating current plants of the day were single phase; second, these plants operated at a frequency of 133 cycles per second, and subsequent studies revealed that this frequency was not well suited for that type of motor. By 1895, however, its development through the aid of many other electrical engineers, was far enough advanced so that a good commercial motor became available.

The invention of the induction meter by Oliver Shallenberger was vital and important in the growth of the electrical industry. Until the invention of this interesting and much needed device, there was no instrument to measure the quantity of alternating current supplied to the consumer. While the meter operated on the same fundamental principles as the Tesla motor, Shallenberger invented the meter entirely independently of Tesla. While Shallenberger was observing the movement of a spring in an alternating current arc lamp, under the influence of a shifting magnetic field, the idea of the induction meter came to him. Within 2 weeks after he had conceived the idea, he designed and built a most successful alternating current meter of the induction type. This meter was accepted immediately as a success by the electrical industry and the public—a long time before the induction motor was accepted as such. While Shallenberger's particular meter has long been discarded, its influence on the development of the struggling industry was great indeed. He died in 1898, before he had an opportunity fully to appreciate or to enjoy the success of his labors.

The engineering talents of the late Benjamin G. Lamme, an engineer and inventor endowed with unusual ingenuity, resourcefulness, and good judgment, presented to the art the synchronous converter, the rotary condenser, and also the electrical design of the 5,000-hp generator—a far bigger generator than had ever been built up to that time—



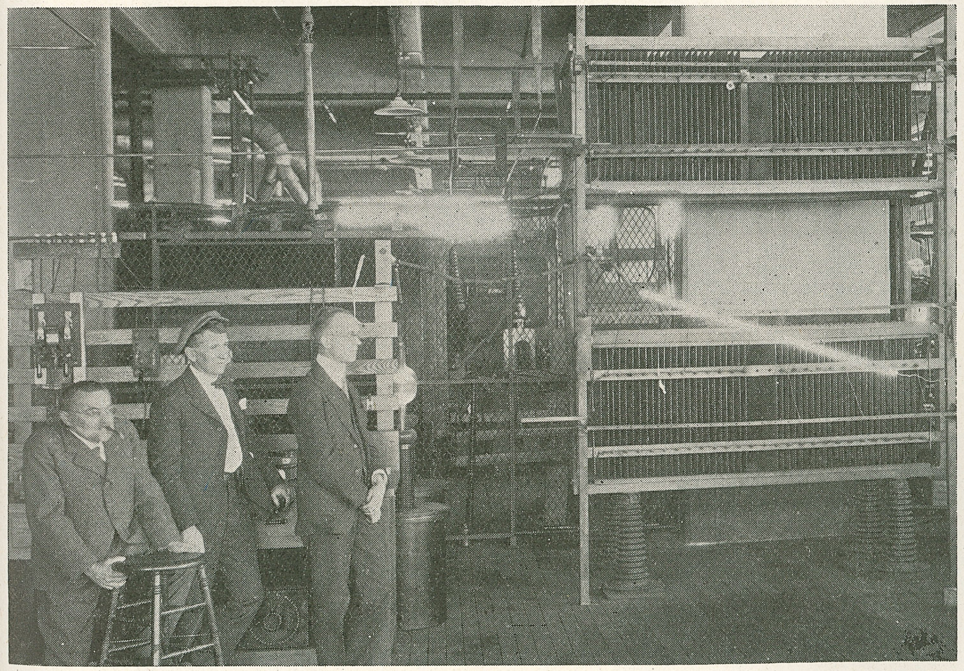
Westinghouse Photo

Early laboratory model of Tesla motor with wound rotor and slip rings

which inaugurated the hydroelectric power development at Niagara Falls in 1895. This type of generator has persisted to the present day. The single-phase railroad motor and the introduction of the squirrel-cage induction motor with high starting torque, were the individual works of Mr. Lamme.

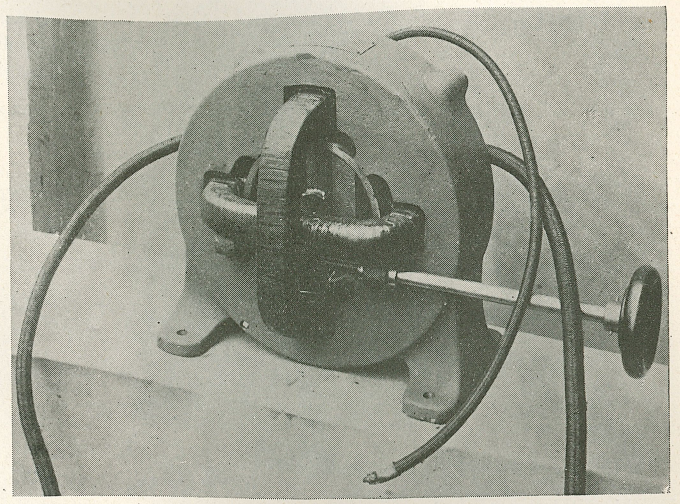
Of the contributions of Charles P. Steinmetz there is little to tell electrical engineers; they all know, and they knew him and recognized him among the leaders of modern science. His personal contributions to the science and the art of long distance power transmission by alternating current were many and valuable. To me, however, it has always seemed that his greatest contributions to the electrical art of our day were his writings, embracing the results of theoretical and experimental scientific investigations. In these is laid an invaluable mathematical foundation for the design of electrical machinery. His work in this respect has no equal in our day.

Elihu Thomson's contributions to the electrical industry have been so many and are so generic in character that it is almost impossible to select any one contribution from his work of the last half century which overshadows in importance and value any of his others. His remarkable depth and range of scientific knowledge have influenced in a major way the development in every field of electrical endeavor. A master of industrial research, he invented many early types of lightning arresters, magnetic blowout switches, the induction regulator, and the single-phase repulsion motor. From a power transmission and distribution standpoint, one of his most important contributions was his proposition to use oil for insulating and cooling transformers, a practice now universal the world over and upon which the success of the progressive and ever increasing power transmission potentials has depended.



Steinmetz observing artificial lightning flash in his laboratory, February 1922

I have selected these men as the most outstanding among all the electrical engineers and inventors of that pioneer period, the closing decade of the last century; their accomplishments more than those of any other group, made possible the high state of the art of transmitting and distributing electric energy as we find it and as we enjoy it today. It was through their insight into, and their solution of, the technical problems that beset them, and by their foresight in reading the future promises of their time, that they were able to blaze the trail not alone for their contemporaries, but for future generations as well. It was their glory to be able to catch a glimpse of what was before us while the rest of the world wondered. On the traditions of the past, a great future for electricity and for the transmission of electrical energy is predicated. However, as we of the electrical fraternity hope for continued progress, we must remember that our hopes can be fully realized only by remaining true to the greatest of those traditions, "to produce and to serve," and by cherishing the ideals and emulating the ceaseless activities of such pioneers as those mentioned.

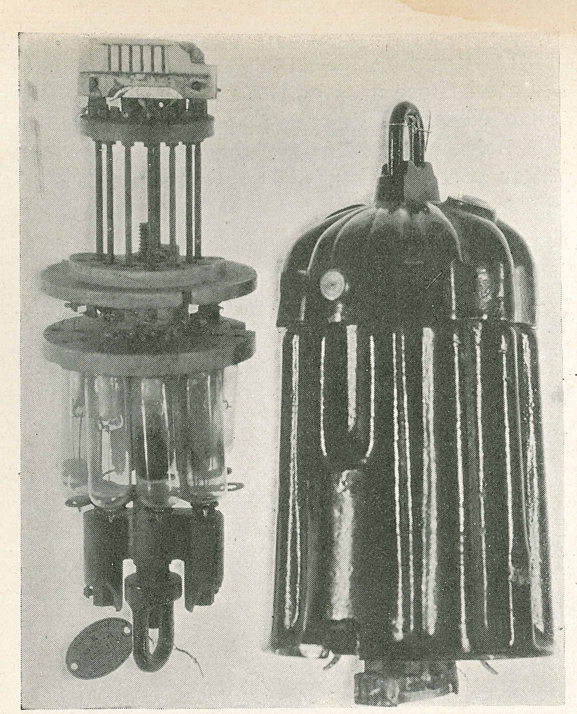


Thompson induction regulator of the late '90's

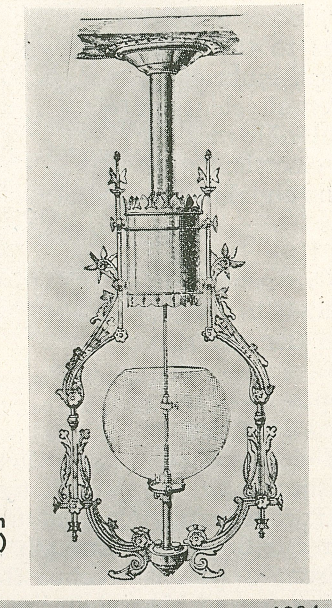
All 6 of these men possessed the scientific spirit. They were truly men of research, with patience and vision, always seeking earnestly and hopefully for new knowledge, more fully to understand Nature's laws as they are, and more effectively to use those laws for the benefit of humanity.

Some Early Forms of Electric Lamps

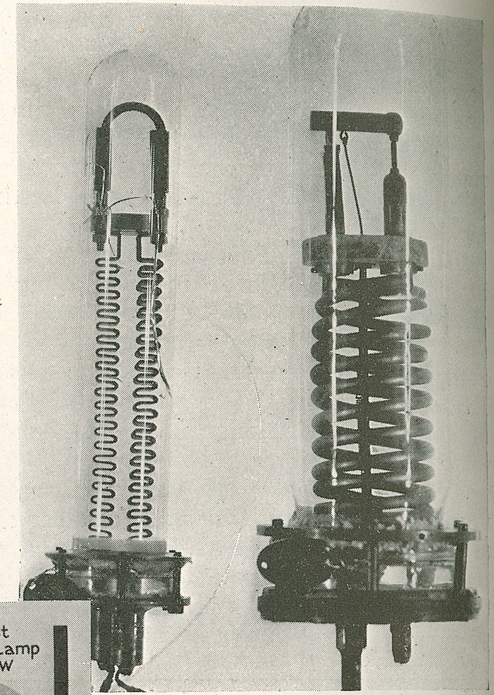
Arc lighting, now practically nothing but a memory, was the electrical industry's first commercial load. The fortifications of Paris were arc-lighted in 1870; in 1875 arc lamps came to America (Wallace Farmer system) where commercial success began about 1880 under the developments of Brush, Thomson-Houston, Weston, Waterhouse, and others. The incandescent lamp, however, and particularly since the development (1906) of metallized filaments, has waged a winning battle. Although, of the total present power output in the United States, lighting accounts for only about 25 per cent, as late as 1912 it constituted half the central station load



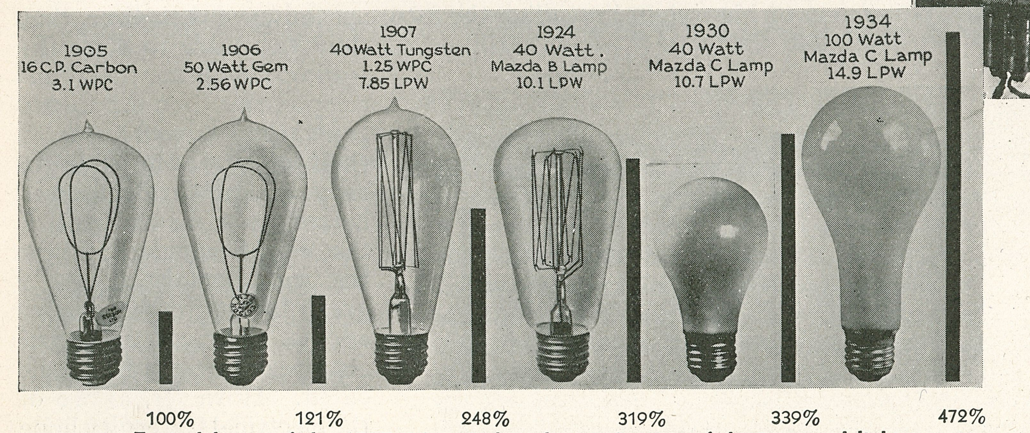
The Nernst lamp (above), more efficient than the early carbon filament lamps, burned in the open air and bade fair to win wide acceptance until succeeded by the Mazda
(Westinghouse photo)



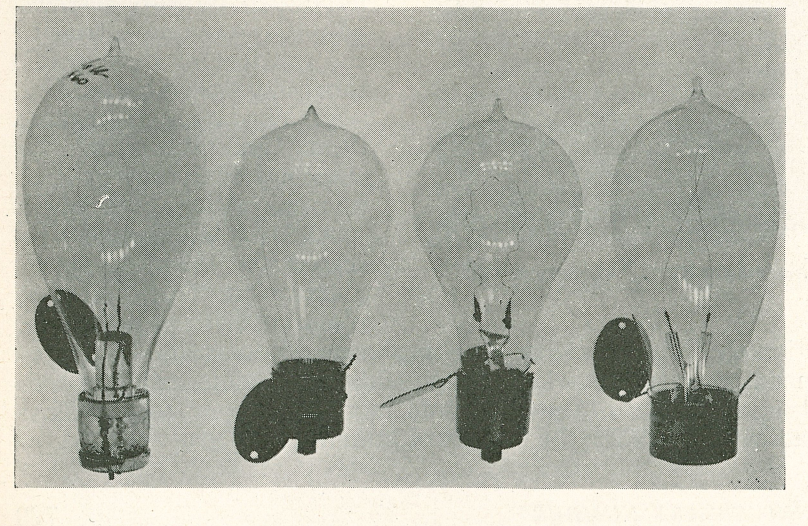
Right—An early design of ornamental open carbon arc lamp for interior use (list price $65!)
(General Electric photo)



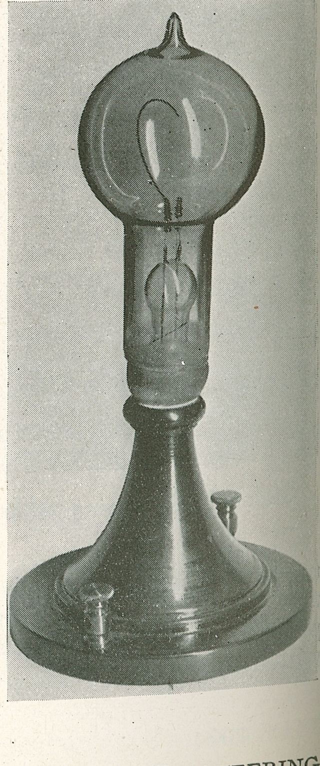
Early forms of incandescent lamps said to have been in operation almost a year before Edison developed his commercially practicable incandescent lamp
(Westinghouse photo)



Typical lamps of the 1905–34 period, and an indication of the improved light efficiency of incandescent lamps
(General Electric photo)



Left—from left to right—the "stopper" lamp that lighted the 1893 Chicago Fair; Weston lamp, Weston base, 1882; U.S. Lamp Co. lamp, Weston base, 1882; Sawyer-Mann lamp, 1879, Thomson-Houston base
Westinghouse photo)



Right—Edison lamp first commercially used; carbonized bristol board "horseshoe" filament; produced Nov. 1879–May 1880; total height $8\frac{1}{16}$ in.; bulb diameter $3\frac{13}{16}$ in.
(General Electric photo)

Lighting "A Century of Progress"

By W. D'Arcy Ryan,* Associate A.I.E.E., General Electric Co., Schenectady, N. Y.

Since the Columbian Exposition at Chicago in 1893 gave to the world its first large outdoor display, electric illumination has played a vital and striking part in the great expositions. At San Francisco in 1915 the illumination was classed by the International Jury of Award as a "Decorative Art"; at Chicago in 1933 the lighting was conceded to be an outstanding feature of the exposition in spite of the fact that it was almost an afterthought. In this short article the author gives a general description of the exterior lighting effects; illustrates some of the equipment used and the results obtained. —Editor.

IN JANUARY 1933, approximately 4 months before the opening date of the Exposition, engineers of the General Electric Company and the Westinghouse Electric & Manufacturing Company were commissioned to complete the exterior lighting of Chicago's *A Century of Progress* exposition. Obviously, the lighting of a group of buildings of ultra-modernistic or futuristic design such as those comprising the exhibit buildings at this exposition introduced many problems in lighting if the daytime architectural character was to be preserved at night. The late Joseph Urban, with his flair for bold color treatment and effects and ably assisted by his associates Teagan and Scott had skilfully used color to vitalize and unify the grouping of the buildings for daytime effect. At night the medium by which to accomplish these same ends was light.

Many engineers and designers contributed to the accomplishment of the lighting results, aided by the tireless and efficient efforts of many contractors in constructing and installing the equipment. I should like to mention by name these many engineers, designers, and contractors who are entitled to share in whatever credit attaches to the results obtained, but I fear that if I were to attempt to formulate such a list I should overlook many worthy contributors. I feel obliged, however, to acknowledge the work of E. D. Tillson who during the period that he was associated with the exposition as illuminating engineer laid the groundwork which proved very valuable to us who followed, and R. E. Barclay whose enthusiastic studies in the application of the gaseous conductor tube resulted in many striking and beautiful effects by these light sources. To C. W. Farrier and his staff is due the credit for the design of many of the lighting standards and much helpful and constructive criticism of the lighting scheme. The installation of the lighting equipment, including the design and installation of the entire electrical distribution system, was under the capable supervision of J. L. McConnell, electrical and mechanical engineer of the exposition, whose willing coöperation made it possible for us to overcome many obstacles.

In this paper I shall confine myself to a general description of the exterior lighting effects, and trust that a more detailed description of the numerous elements entering into the general scheme will be recorded in the technical press by those responsible for their development. Also, although consideration of the lighting of the building interiors and of the exhibits and exhibitors' buildings is outside the scope of this paper, I want to pay tribute to those responsible for the design and execution, for to my mind these lighting effects in many instances exceeded those of the exterior.

The exposition site (Fig. 1) contains approximately 424 acres and forms a strip along the shore of Lake Michigan approximately 3 miles long and varying in width from 450 to 3,200 ft. Northerly Island is separated from the mainland by 2 lagoons covering approximately 80 acres. In view of the attenuated shape of the grounds we regarded it to be a function of the lighting to consolidate the grouping of the buildings and create the appearance of a unified whole. Also, owing to the generally low types of buildings prevailing, it became a secondary consideration in planning the lighting to elevate, psychologically the exposition when viewed from the many points of vantage throughout the grounds. The buildings were of an entirely new style of architecture compared with expositions of the past, presenting large flat surfaces painted in a wide variety of colors, and with viewing terraces at many levels and therefore demanding an entirely new approach from the standpoint of lighting the buildings themselves and the surrounding grounds. The probability of fog and smoke became a factor of consideration in the determination of surface brightnesses and probable viewing distances. All these considerations and many others including a limited budget entered as compromising factors into the determination of the most appropriate and most efficient type of lighting equipment, a detailed description of which would require more space than is warranted here.

The exterior lighting—which we may consider under the topics of building floodlighting, grounds lighting, and spectacular lighting—made up a total connected load of approximately 3,000 kw. Power was purchased from the Commonwealth Edison Company and distributed through the secondary network 4-wire Y 120/108 volts. Mr. McConnell has stated that in only one imperative consideration is the electrical installation at *A Century of Progress* directly comparable to ordinary engineering work,

* Deceased March 14, 1934; see p. 636, ELECTRICAL ENGINEERING, April 1934.

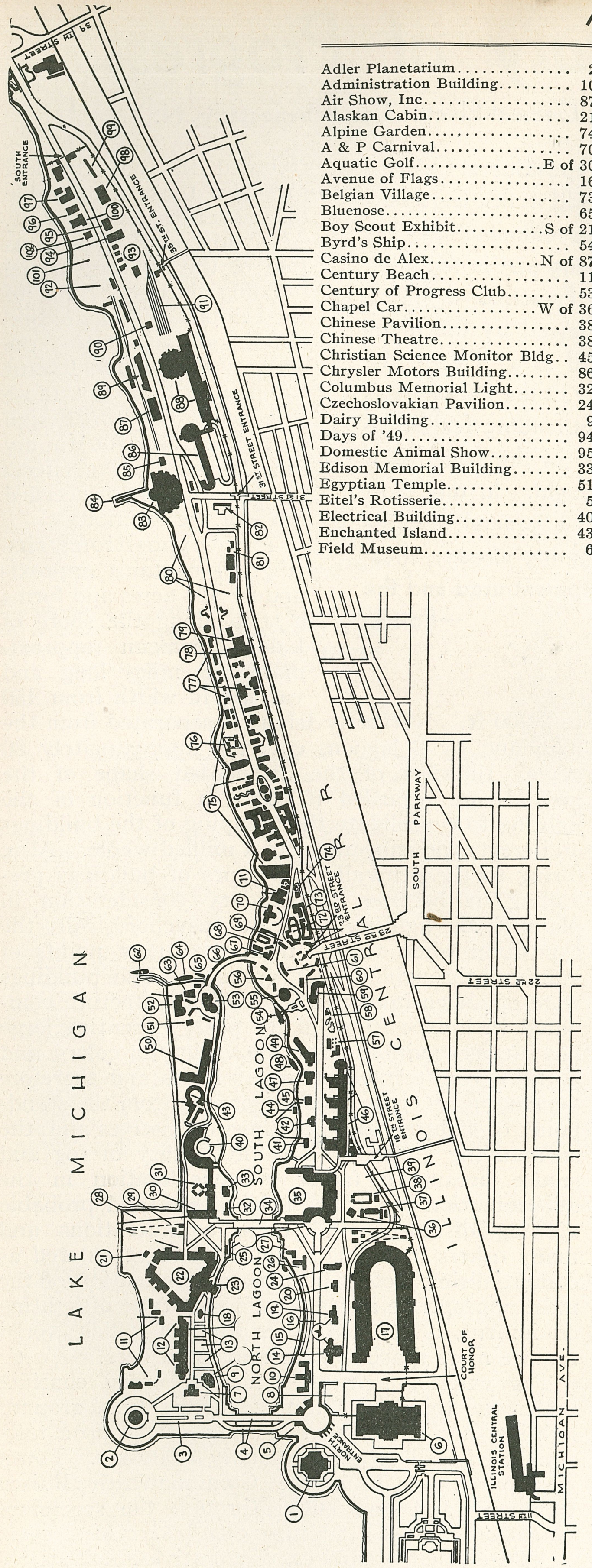


Fig. 1. Plan of "A Century of Progress" exposition grounds along the lake front at Chicago, Ill. (For key see adjoining column.)

Alphabetical Key to Exposition Plan

Adler Planetarium	2
Administration Building	10
Air Show, Inc.	87
Alaskan Cabin	21
Alpine Garden	74
A & P Carnival	70
Aquatic Golf	E of 30
Avenue of Flags	16
Belgian Village	73
Bluenose	65
Boy Scout Exhibit	S of 21
Byrd's Ship	54
Casino de Alex	N of 87
Century Beach	11
Century of Progress Club	53
Chapel Car	W of 36
Chinese Pavilion	38
Chinese Theatre	38
Christian Science Monitor Bldg.	45
Chrysler Motors Building	86
Columbus Memorial Light	32
Czechoslovakian Pavilion	24
Dairy Building	9
Days of '49	94
Domestic Animal Show	95
Edison Memorial Building	33
Egyptian Temple	51
Eitel's Rotisserie	5
Electrical Building	40
Enchanted Island	43
Field Museum	6
Firestone Building	59
Florida Gardens	13
Foods and Agricultural Building	12
Fort Dearborn	76
Garden of Comfort	57
Gas Industry Hall	79
General Cigar Company Exhibit	69
General Exhibits Group	46
General Motors Building	83
Goodyear Field	92
Grand Stand	15
Great Beyond	96
Greyhound Service Station	98
Hall of Religion	49
Hall of Science	35
Hall of Social Science	30
Havoline Thermometer	56
Hollywood	52
Home and Industrial Arts Group	77
Home Planning Hall	78
Horticultural Building	50
101 Ranch	101
The Hub—Henry C. Lytton & Sons	61
Illinois Host House	19
Indian Village	81
Infant Incubator	67
Italian Pavilion	26
Italian Restaurant	27
Japanese Pavilion	37
Lama Temple	36
Machinery Demonstration Area	91
Maya Temple	82
Mexican Village	100
Midway	75
Miller High Life Fish Bar	18
Moroccan Village	72
Muller Pabst Restaurant	47
Norwegian Ship	64
Old Heidelberg Inn	71
Outdoor Railway Exhibit	91
Pabst Blue Ribbon Casino	53
Palwaukee Amphibian Ramp	85
Picnic Grounds	28
Planetarium Bridges	4
Poultry Show	93
Radio & Communications Bldg.	31
Rapid Transit Terminal	8
Receiving Depot	99
Rolleo (Log Rolling)	102
Schlitz Garden Restaurant	25
Science Bridge	34
Sears, Roebuck Building	14
Shedd Aquarium	1
Show Boat	44
Sinclair Prehistoric Exhibit	58
Sky-Ride	29
Soldier Field	17
Solomon's Temple	11
Spoor's Spectaculum	63
States Building	22
Streets of Paris	68
Submarine S-49	E of 26
Swedish Pavilion	20
Terrazzo Promenade	3
31st Street Boat Landing	84
Time & Fortune Building	41
Travel & Transport Building	88
23rd Street Bridge	66
23rd Street Steamer Landing	62
Ukrainian Pavilion	97
U.S. Army Camp	80
U.S. Government Building	23
Whiting Corp. & Nash Motor Bldg.	90
Walgreen's Store	60
Wings of A Century	89
World A Million Years Ago	55

"Century of Progress" Outdoor Lighting Standards

(See facing page)

A Floodlighting standard. Equipped with 18 200-watt floodlights. Installed around Planetarium, west side of Electric Building, and west side of the Hall of Science.

B Clover leaf standard. Equipped with 45 8 x 18-in. opal glass cylinders with 200-watt multiple mazda lamps and 3 200-watt floodlights. Installed at 12th Street entrance and in General Exhibits Building courts.

C Floodlighting standard. Equipped with 16 200-watt floodlights. Installed around Travel and Transport Building.

D Lantern standard. Equipped with a 6,000-lumen series mazda lamp. Installed along Lief Eriksen Drive.

E Mercury-neon pylon. Equipped with 48 mercury arcs and 48 neon arcs. One unit installed in Court "A" of General Exhibits building.

F Opal glass pylon. Containing 144 100-watt multiple mazda lamps. Four units installed in east court of the Hall of Science.

G Stair lighting unit. Small size, equipped with 26 60-watt multiple mazda lamps. Large size, equipped with 76 60-watt multiple mazda lamps. Installed at 23rd Street entrance and at various other locations throughout the grounds.

H Zodiac standard. Equipped with 18-in. opal glass ball and 500-watt multiple mazda lamp, surrounded by a bronze band depicting the characters of the Zodiac. Installed along approach to the Planetarium.

Fig. 2. Some "Century of Progress" outdoor lighting standards

(For description, see facing page)

and that is that it had to be made safe. Many interesting and novel features were introduced into the electrical distribution system by Mr. McConnell, many of which he has described in the April 27, 1933 issue of the *Electrical World*.

The colored plates forming part of this presentation (beginning facing page 736) afford a general idea of the appearance of the exposition at night. Obviously, they lack the intricacy of detail visible to the visitor who viewed the exposition on the grounds, and similarly any description of the lighting is lacking in the details of application so important in obtaining the results. The floodlighting of the building facades was accomplished in general by floodlights either located on the buildings themselves or grouped on structural standards of appropriate design and screened from direct view. All floodlights were of the enclosed type, ranging in capacity from 200 to 1,000 watts. In many instances the floodlights were equipped with colored door glasses, as it was found that much better results were obtained in flooding colored surfaces with light of approximately the same color as the surface. A wide range of colors, having coefficients of reflection of from 4 to 71 per cent, were encountered in the large flat composition-board surfaces of the various buildings. The viewing distances were relatively great. Many of the buildings had balconies serving as promenades. The atmospheric conditions peculiar to the Chicago lake front were, at times, very unfavorable. These conditions influenced the lighting treatment of the different buildings and made each one a subject of study and trial. Difficulties in concealing the lighting equipment were overcome by constructing screens or shields harmonizing with the building architecture where possible.

Gaseous tube lighting of building exteriors had its debut at this exposition and made possible many interesting and beautiful effects. A variety of gases and combinations of gases together with colored glass tubes provided the many colors used throughout the grounds. In general these tubes were applied in such a manner as to conceal the tube itself and to reflect the light from the building surface. One outstanding exception to the use of the tube for indirect lighting, and one of the most striking features of the lighting, was the "cascade" formed at the rear of the electrical court in which approximately 4,650 ft of blue tube was used. An innovation in the application of gaseous tubes was the use of the mercury-neon pylon rising 38 ft above the ground, triangular in section and constructed in louvre form to provide coves for the light sources. Alternate louvres on each face were equipped with mercury arcs and neon arcs. These arc lamps were of the hot cathode type, and operated as half wave rectifiers from an alternating current source, thus making it necessary to start the lamps each half-cycle.

These arcs, in common with all arcs, have a negative voltage characteristic. That is, after they are started, the voltage across the arc decreases as the current increases, at a rate and to a minimum depending upon the constants of the circuit in which the arc is established. This necessitated a ballast, and in this case an induction ballast was used which served also as a starting transformer. Two turns of high voltage insulated wire were placed around each reactor, and all the reactors on one phase were connected in series by means of this primary winding. Starting was accomplished each half-cycle by discharging a condenser through a thyratron tube into these series turns, the time of the discharge being controlled by means of a motor driven timer in the grid circuit of the thyratron.

When starting occurs late in the cycle the effective light is small and, *vice versa*, if the starting is earlier the effective light is greater. Taking advantage of this characteristic, a great variety of tints thus were obtained by controlling the dimming of the 2 sets of lamps in orderly sequence and thus obtaining changing proportions of neon and mercury light. In order to reduce the flicker to a minimum the number of lamps on each phase were kept balanced on each of the 4 faces of the tower. Individual lamps produce 60-cycle flicker, but the composite light on the buildings shows no appreciable flicker.

The problem presented in lighting the grounds and roadways also was influenced by the radically different type of architecture employed at the exposition, and resulted in the design of an entirely unique group of lighting standards. Efficiency of light output suffered very little in developing these futuristic lighting standards; in fact, most critics will give them a higher rating as lighting units than as objects of beauty. A general idea of these stand-

"Century of Progress" Outdoor Lighting Standards

(See facing page)

I Tubular lamp standard. Equipped with 100-watt 32-in. tubular multiple mazda lamps. 22 lamps for single plane standards and 44 lamps for 2-plane standards. Installed along the Avenue of Flags.

J Mushroom standard. Equipped with 150-watt multiple mazda lamp, refractor, and micarta shade. 500 units installed throughout grounds.

K Shell globe standard. Equipped with 500-watt B. F. multiple mazda lamps and shell globes. Installed around Dairy, Agriculture, States, and Electric buildings.

L Shower standard. Equipped with 352 15-watt flame-tint medium-screw-base multiple mazda lamps. 10 standards installed in the Court of States.

M Rainbow standard. Equipped with 4 500-watt floodlights. Installed in Lief Eriksen Drive at south end of grounds.

N Bridge standard. Equipped with a 500-watt floodlight. Installed on 12th Street bridge.

O Lighting Turrett. Equipped with 24 1,000-watt floodlights to illuminate reflecting surface, and 8 24-in. 1,500-watt incandescent searchlights for illumination of flags. Installed in center of 12th Street entrance.

P Tree lighting unit. Equipped with 6 200-watt floodlights. Installed at bases of trees throughout grounds.

Fig. 3. Some "Century of Progress" outdoor lighting standards

(For description, see facing page)

ards may be obtained from Figs. 2 and 3 and the related brief descriptions of their equipment.

General lighting throughout an exposition must be consolidated if the exposition is to stand apart as a unit. This was particularly true of Chicago because of the elongated form of the grounds and its adjacency to the city with its electric signs, illuminated buildings, etc. Efforts in this direction took the form of a battery of 24 36-in. arc searchlights located at the southern extremity and spreading a fan of light beams over the grounds, a battery of 17 36-in. incandescent searchlights fanning out from the electrical building, and a group of electric fountains, 3 in the south lagoon and 1 in the court of the Electrical Building. The 3 fountains in the south lagoon were located approximately 100 ft off the west shore and 150 ft apart. The center fountain, containing 70 incandescent floodlighting projectors arranged in four colors, was flanked by 2 fountains, each containing 36 similar projectors in clear light. The water effects were identical and were operated in synchronism by means of thrustor valves actuated through a central controller. The color changes in the center fountain were accomplished by means of a thyratron reactor system controlling the 4 circuits of red, green, blue, and amber light in a sequence of combinations the complete cycle of which required 10 minutes to complete. Each fountain circulated 1,200 gal of water per minute; the connected lighting load was 18 kw each for the 2 clear-light fountains and 67.5 kw for the central fountain. A 75-hp motor direct connected to a centrifugal pump supplied the necessary water from the lagoon. The fountain in the electrical court had a 3-step central basin at the center of a pool 60-ft in diameter. The water effects at each level consisted of a spray emanating from a circular ring of jets; the water was illuminated by static colored light, each level in a different color. These bands of color were reflected from a 32-ft diameter cone shaped canopy surfaced with chromium plated sheet copper and supported 50 ft above the fountain on 6 structural steel legs. The reflected light from this specular surface created an interesting mat of mobile color and added a warm glow to the court. A 25-hp motor directly connected to a centrifugal pump circulated 1,200 gal of water per minute through the fountain. The total connected lighting load was 42 kw.

The climaxing feature of the spectacular lighting was furnished by the battery of 24 36-in. arc searchlights spreading a fan of varicolored beams of light over the grounds, and the battery of 17 36-in. incandescent searchlights the beams of which, crossing above the "morning glory" fountain in the electric court, contrasted vividly with the blue of the gaseous tubes forming the cascades and with the warm tints of the fountain colors. The group of arc searchlights known as the scintillator were arranged on a 2-step platform, each light taking 125 amp at 110 volts dc and producing a beam candle power of 60 million or a total of 1,440 million for the 24 units. A trained corps of operators maneuvered the group of lights through fantastic forms and color changes and directed the beams on clouds of steam, smoke bombs, etc., to provide many weird and striking effects.

Each of the group of 17 36-in. incandescent searchlights were equipped with a 3-kw incandescent lamp and each was operated without attendants at a fixed position, the beams intersecting over the axis of the fountain and fanning out over the south lagoon.

Statistical data (Table I) relating to the lighting features of an exposition, while at times interesting for purposes of comparison, are of little value as a guide to the engineer confronted with the problem of lighting an exposition. To determine why this is so we have only to review past expositions and note their variance in architectural style, landscaping, and general character. It is an inherent and fundamental purpose of expositions to mark epochs of time; to show the advances in materials and methods. Consequently the engineer responsible for planning the lighting for an exposition must approach his problem with the purpose of the exposition in mind and intent upon supporting the style and effects contemplated by the architects. Originality and appropriateness should be the outstanding characteristic of lighting installations of this class and these arise from the circumstances surrounding individual expositions rather than from the records of those in the past.

Table I—General Data—A Century of Progress

Number of transformer vaults installed	45
Number of transformers installed (10 to 333 kva)	177
Total connected load (kva)	27,562
Exterior lighting load (kw) (exclusive of amusements)	2,750
Exterior lighting standards—approx	1,160
Incandescent lamps installed (10 to 3,000-watt)	130,000
Primary feeder cable (ft)	300,940
Secondary feeder cable (ft)	252,236
Building feeders (ft)	407,061
Distribution Cable—Roads & Path Lighting (ft)	152,760
No. 00 wire for general distribution (ft)	317,000
No. 12 wire for general distribution (ft)	2,625,000
Pump log for cable runs (ft)	263,000
Raceway for wire runs (ft)	138,000
Gaseous tubes installed (ft)	19,877
Power consumption, total 170 days (kw)	35,111,852
Average consumption per 24-hour day (kwhr)	206,540
Peak load (kw)	18,952
Average watts per sq ft interiors	3.77
Total water requirements per day (gal)	10,000,000
Projector type units purchased by Exposition Company	
200-watt floodlights	1,600
500/1,000-watt floodlights	1,000
24-in. incandescent searchlights	72
36-in. incandescent searchlights	18
36-in. arc searchlights	24
250 to 1,500-watt underwater floodlights	277
Total paid attendance	22,321,497
Average per day, 170 days	131,303
Total area of enclosed grounds (acres)	424
Average of lagoons in grounds (approx. acres)	80
Interior lighting fixtures	7,762
Illumination intensities, building walls and roadways (foot-candles)	0.1 to 9

Additional articles on the subject of illumination as applied at the "Century of Progress" exposition, together with discussion of same, will be found in the February 1934 Transactions of the Illuminating Engineering Society. They are entitled:

1. Illumination of A Century of Progress Expositon, Chicago, 1933. W. D'A. Ryan.
2. Unique Lighting at A Century of Progress. L. A. S. Wood and Charles J. Stahl.
3. Lighting Features of the Fair. J. L. Stair, W. V. C. Foulks and W. E. Folsom.
4. Century of Progress Exhibit Lighting. C. M. Cutler.

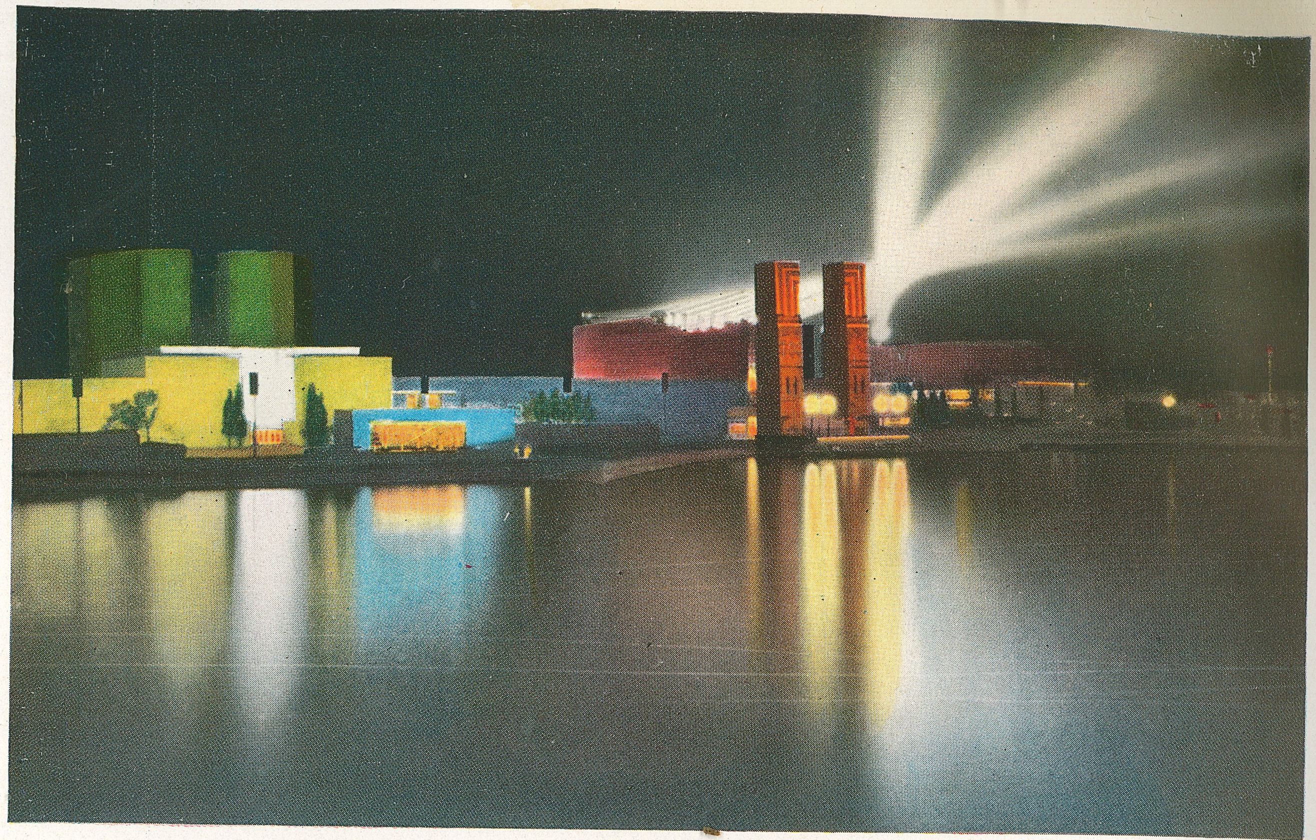
These papers give interesting details and amplification of the material here presented by Mr. Ryan at the request of the A.I.E.E. committee on production and application of light.

Courtesy General Electric

GENERAL VIEW TOWARD NORTHERLY ISLAND

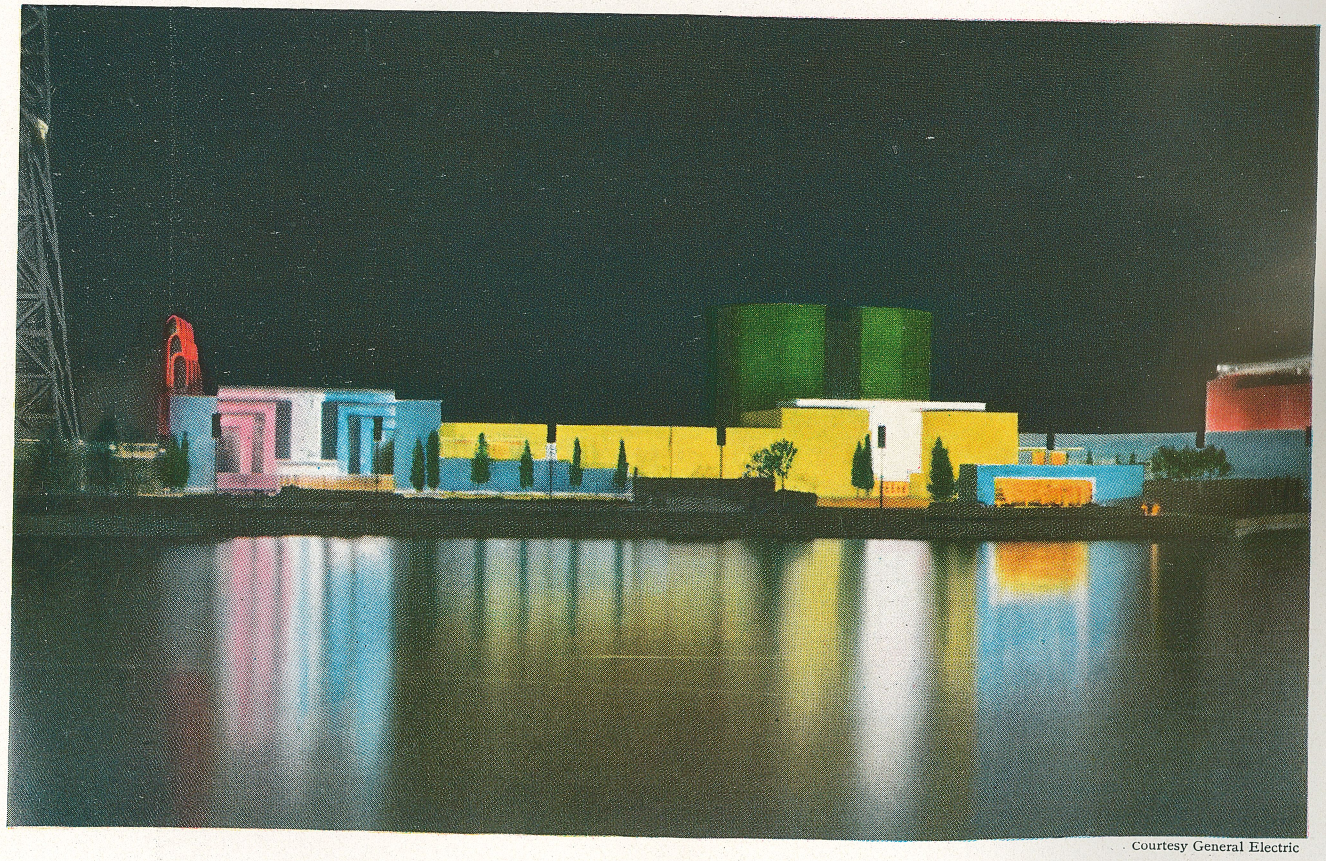
Courtesy General Electric

TWELFTH-STREET ENTRANCE AND BRIDGE



Courtesy General Electric

ELECTRICAL BUILDING, AND RADIO AND COMMUNICATIONS BUILDING

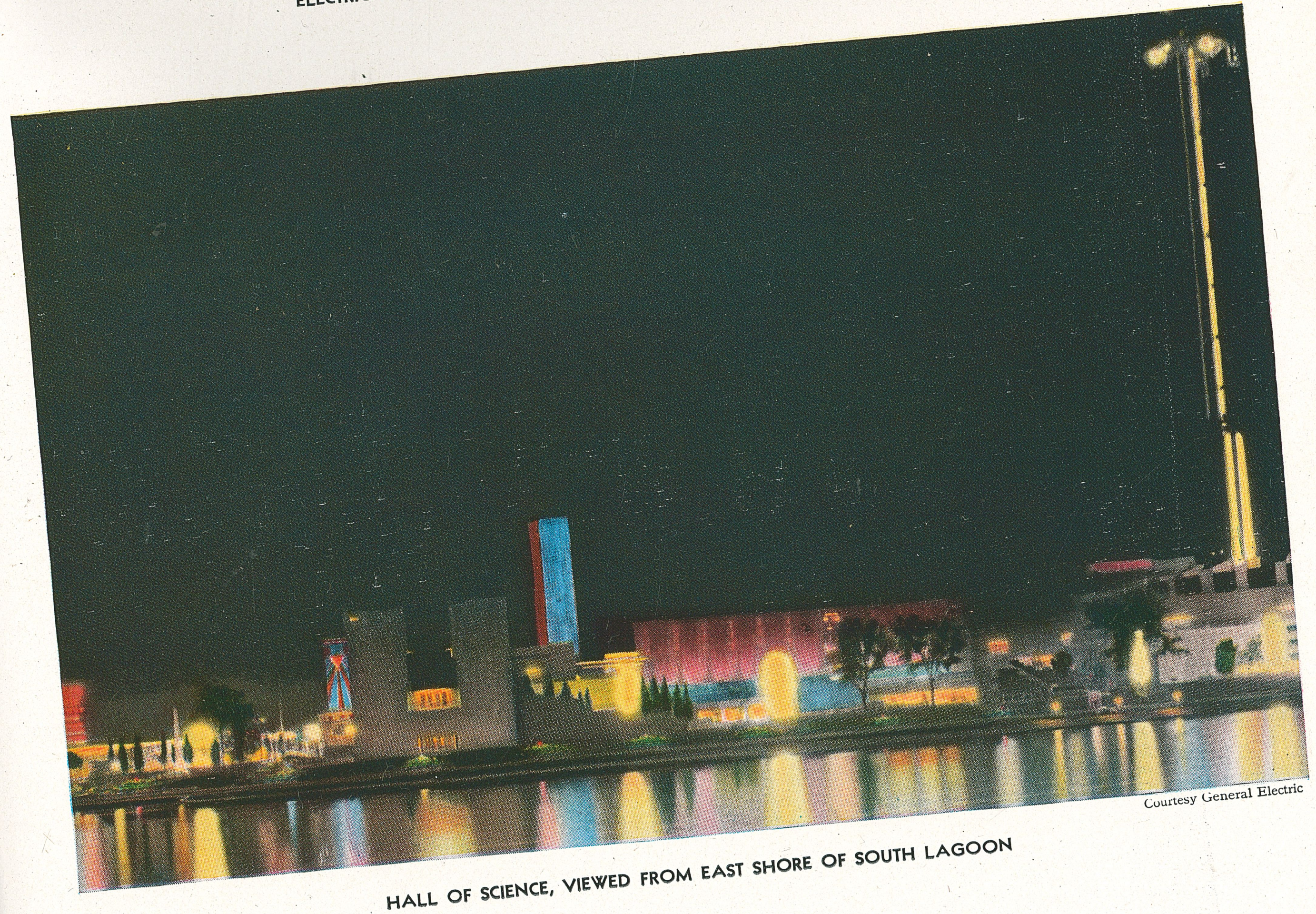


Courtesy General Electric

HALL OF SOCIAL SCIENCE, AND RADIO AND COMMUNICATIONS BUILDING

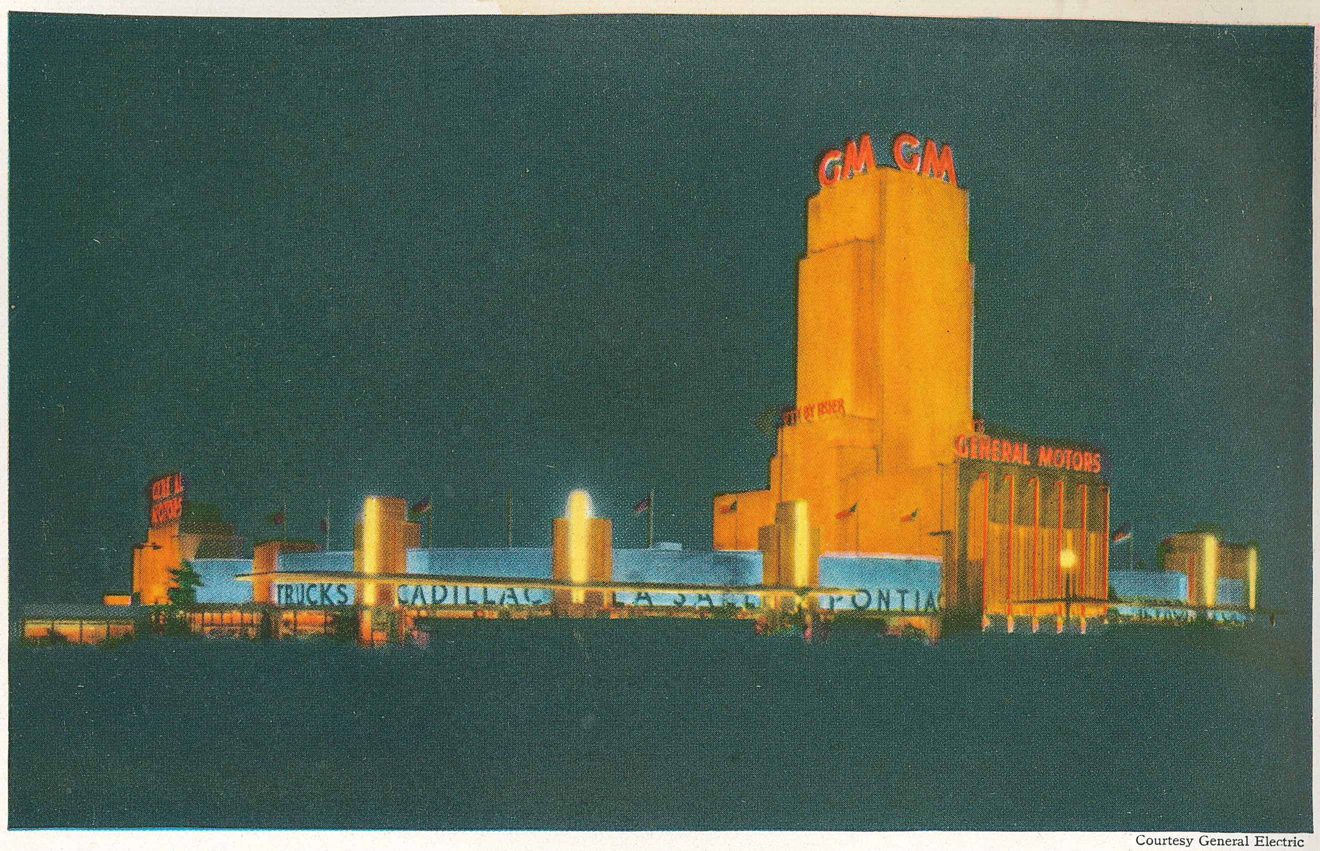
Courtesy General Electric

ELECTRICAL GROUP, VIEWED FROM WEST SHORE OF SOUTH LAGOON



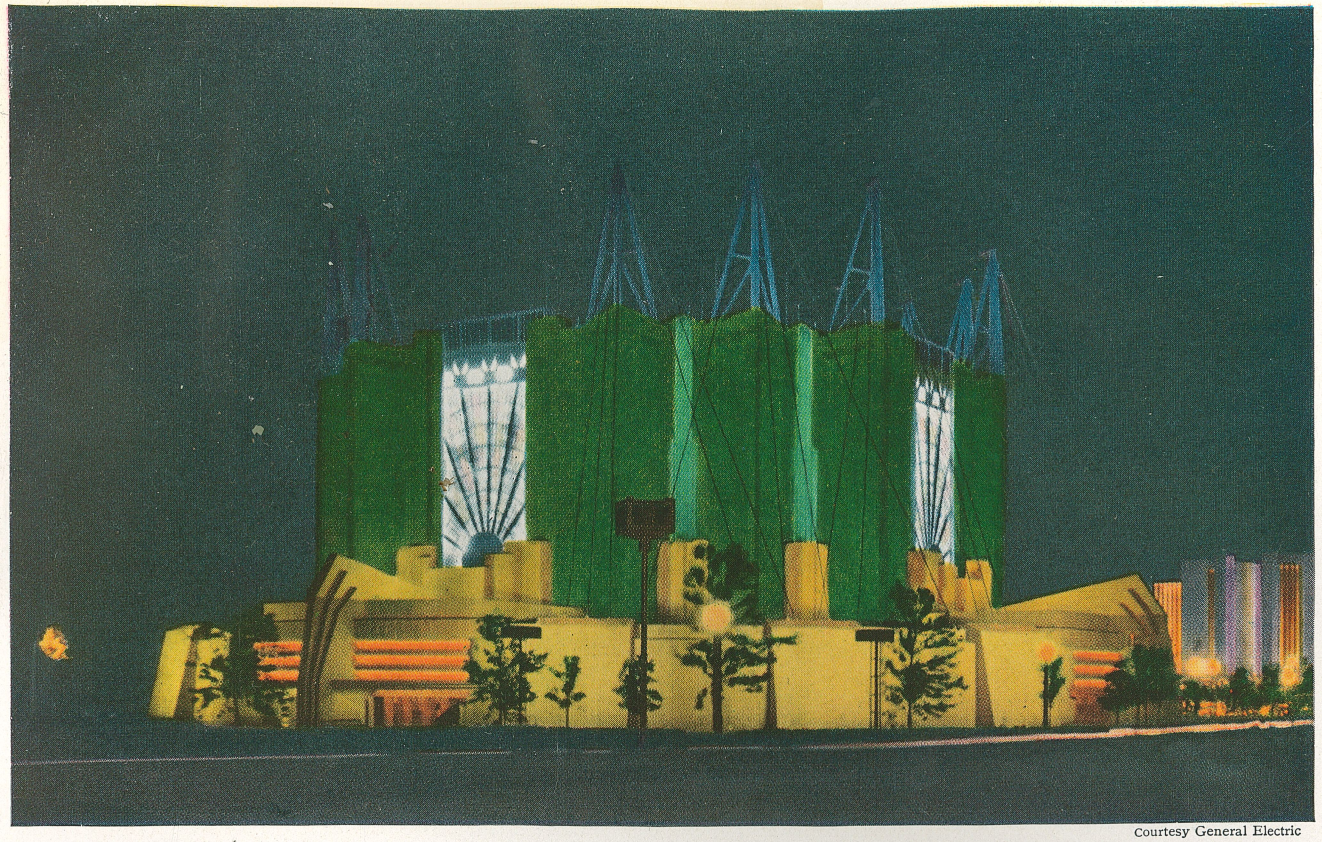
Courtesy General Electric

HALL OF SCIENCE, VIEWED FROM EAST SHORE OF SOUTH LAGOON



Courtesy General Electric

GENERAL MOTORS BUILDING

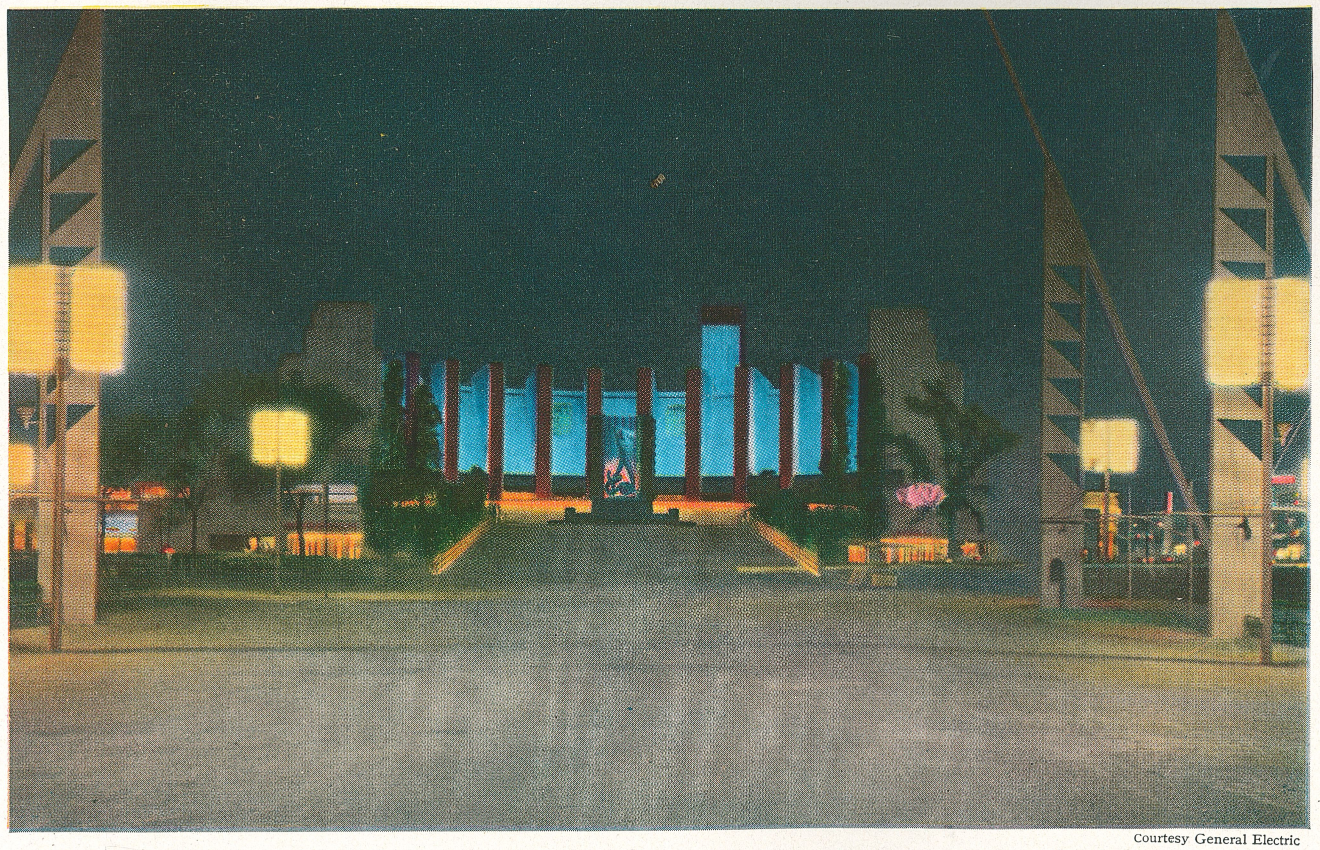


Courtesy General Electric

THE TRAVEL AND TRANSPORT BUILDING

Courtesy General Electric

GENERAL EXHIBITS GROUP ON LEIF ERIKSEN DRIVE



Courtesy General Electric

NORTH ENTRANCE TO THE HALL OF SCIENCE

Courtesy General Electric

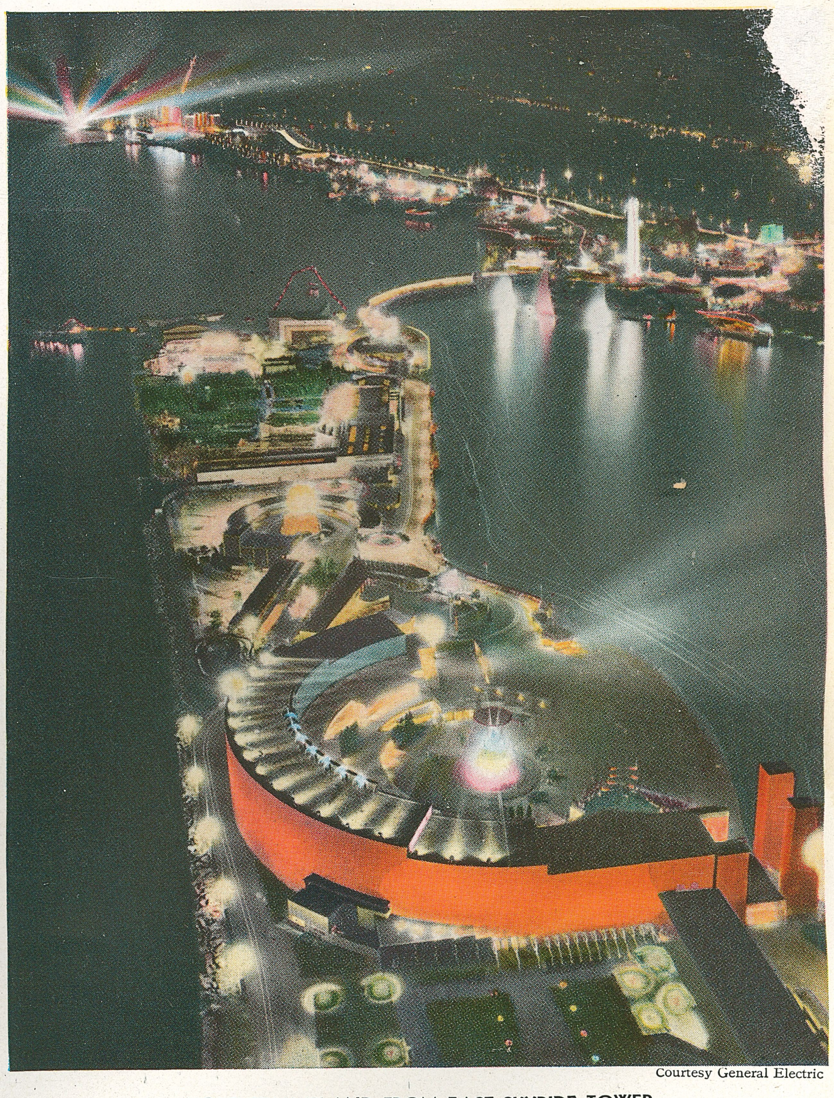
THE FEDERAL BUILDING

Courtesy General Electric

MERCURY-NEON PYLON IN COURT A OF THE GENERAL EXHIBITS GROUP

Courtesy General Electric

COURT OF THE ELECTRICAL BUILDING, "MORNING GLORY" ELECTRIC FOUNTAIN IN FOREGROUND



Courtesy General Electric

NORTHERLY ISLAND FROM EAST SKYRIDE TOWER

Courtesy General Electric

SCINTILLATOR FAN, AS SEEN FROM THIRTY-FIRST-STREET ENTRANCE

Courtesy General Electric

VIEW LOOKING SOUTH FROM WEST SKYRIDE TOWER

Communication—Past and Present

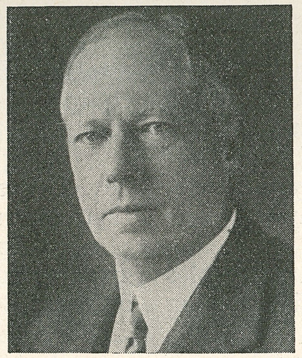
By Bancroft Gherardi, President A.I.E.E. 1927–28

Pointing out that when the A.I.E.E. was founded in 1884 telegraphy was 40 years old and telephony 8 years old, the author traces briefly the significant developments and tremendous growth of electrical communication and the significance and importance of the parallel growth of the Institute. "Both grew out of the extension of our knowledge of certain laws of nature, and both were encouraged in their growth by the social and economic results that were possible from the application of electricity." The record of 50 years of communication development is traced through a half century of Institute publications.

WHEN in May 1884 a group of men, numbering perhaps a hundredth of our present membership, gathered together to found the American Institute of Electrical Engineers, none of them could foresee what the organization itself would grow to be or the future of the industries which would be founded on electrical knowledge. They were interested in the theory and the practical use of electricity. They must have believed that something well worth while would grow out of the application of electricity to the service of mankind, but the tremendous developments that would result from applying electricity to social and economic purposes were concealed then in the darkness of the future. I feel honored in being asked to perform the pleasant duty of recording at this time, when the Institute is completing the first 50 years of its life, what has happened in the communication art during that period.

From the earliest days until the invention of the telegraph, communication between persons at a distance was essentially a matter of transportation. Either a written message was transported by some one of the means then available or the messenger himself traveled, either on foot, on horseback, by stage coach, by boat, or by railroad. With some negligible exceptions used only for specialized purposes, communication was dependent upon transportation and subject to all its limitations. With the invention and development of the electric telegraph, communication by the written message first became independent of transportation. In the United States the first application was by Morse in 1844. Still, however, communication by the spoken word could not be carried on over distances of more than a few hundred feet and conveniently only over distances of a few feet. Alexander Graham Bell in 1876, by the invention of the telephone, offered the possibility of communication by the spoken word between people separated by considerable distances, so that it was no longer necessary for those desiring such communication to meet at a common point to make conversation possible.

When the Institute was founded, telegraphy was 40 years old. The telephone had been invented only 8 years. Radio-telegraphy and radio-telephony did not exist. From the first, a realization of the advantages to be derived from electrical communication led to the rapid development of both telegraphy and telephony. How much of this has taken place during the 50 years of the life of the American Institute of Electrical Engineers is briefly indicated by the following figures. During 1884, there were sent about 40 million telegraph messages in the United States. In 1929, the peak year, just prior to the depression, this figure had increased to 235 million messages. In 1884, there were 198 million telephone messages sent in the United States, and in the peak year 1930 the usage of the telephone had reached the stupendous total of 27,800 million messages. For several recent years the messages sent electrically have greatly exceeded in number the total of the first-class mail pieces in the United States.



It is not a mere coincidence that the life of the American Institute of Electrical Engineers has been paralleled by the tremendous growth of electrical communication. Both grew out of the extension of our knowledge of certain laws of nature, and both were encouraged in their growth by the social and economic results that were possible from the application of electricity.

The early development of the telegraph was closely associated with the railroads which had an urgent need for this form of communication, and telegraph lines were very generally built along the railroad routes. The wires were generally of iron; hard drawn copper was not invented until 1877, and cable development did not start until about the beginning of our 50-year period. Many of the present forms of telegraph circuit had been worked out, including duplex and quadruplex and Baudot's multiplex and printing telegraph, although this form was not applied in this country until a later date. Harmonic telegraphs which foreshadowed our modern carrier telegraph developments had been worked upon by inventors, including Alexander Graham Bell, for a decade or more, and Gray's harmonic telegraph had been given a trial. Following the first temporary success in 1858, permanent transatlantic telegraph